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OF

THE SYMPOSIUM ON BAMBOO FLOWERING AND ITS CONSEQUENCES

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ECO-PHYSIOLOGY OF BAMBOO FLOWERING

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Introduction:

Bamboo flower only once during the lifetime, and then die after flowering. The physiology of bamboo flowering is still not fully understood. Studies are made in Japan to correlate the flowering time and age with the size of the clump, thickness of stem, soil fertility or moisture, exposure to sun, climatic factors or locality differences, but these have not given conclusive results. The problem is now viewed from the standpoint of the balance between genetic and climatic influence in bamboo flowering.

Nearly all bamboo species have their own characteristic lifespan, and flower once in lifetime after a fixed number of years of vegetative growth. The flowering is synchronous over vast tracts of the species, and this phenomenon is called 'gregarious flowering'. The main characteristics of gregarious bamboo flowering are:

(i) it occurs almost in the entire area of the bamboo species,
(ii) it involves almost all major portion of clumps,
(iii) all the culms in a clump flowers,
(iv) flowering is followed by death of the clump,
(v) it follows a regular cycle with a long interval,
(vi) it progresses in a definite direction like a wave beginning at one definite edge of the area,
(vii) it takes a few years (2-4 years) to complete flowering in the area.

The period between two consecutive gregarious flowerings in the same area is fairly constant and called physiological cycle of the particular provenance of a given species. Different period for physiological cycle have been reported for different areas (Dwivedi, 1988).

Different theories for the occurrence of gregarious flowering in bamboo

Although a wide range of research is going on, the flowering of bamboos is still unexplained and mysterious. It has been observed that a flowering bamboo clump does not die until all the vegetative buds (leaf buds) are transformed into flower buds. All the members of bamboo species 'know' when flowering time is at hand. This 'knowledge' seems to be in a genetically imprinted on the biological clock.

Several theories have been proposed on the causes of flowering and death of bamboos which include pathological, periodical, mutational, nutritional, human, resource matching, predator satiation reasons, and bamboo wild life cycle hypothesis (Prasad and Pattanaik, 2002). Kawamura (1927) believed that gregarious flowering is related to the life cycle of the bamboo. Storage of large quantities of starch, sugar and other substances in the clumps aid flowering (Gamble, 1896; Dutta & Tomar, 1964).

Similarly, some workers have tried to relate gregarious flowering with injury, nutrition, climatic conditions, genetical constitution, soil factors, etc. (Nicholson, 1922; Hussain, 1980).

Physiologically, the bamboos differ significantly from other vegetation because of the mechanism of flowering. Generally, most of the bamboo species flower gregariously at fixed intervals and all clumps including those of current year die after flowering. Majority of bamboo fall between the two physiological states of constant flowering (*Bambusa atra)* and constant sterility(*Bambusa vulgaris)*. Some bamboos die soon after flowering *(B. arundinacea)* while others do not die but their growth slows down during the flowering period as in *Phyllostachys* and *Arundinaria sps.* The flowering of bamboo is like setting on an alarm clock which is set to go off at a particular time when all populations of a given species raised from the same seed source, no matter where they are situated, would start flowering at the same time (Kishwan and Goyal, 2006). For example, seeds of *Thyrsostachys oliver* that flowered in Burma in 1891 were sown at Kolkata and Dehra Dun- two places separated about 1,500 km from each other. The clumps raised from these seeds flowered simultaneously at Kolkata and Dehra Dun in 1940 and flowered again in 1987-'88 indicating the flowering cycle of 48 years (Chaturvedi, 1988).

Clements (1956) reported that *D. strictus* introduced in Cuba from the 1912 seeding in Garhwal (Uttar Pradesh) flowered in 1956, indicating a cycle of 44 years. A plantation raised in Taiwan in 1912 from seeds obtained from Bihar (India) flowered in 1969, showing a physiological cycle of 57 years. A plantation of *D. strictus* raised in the Forest Research Institute (FRI), Dehradun, during 1937 flowered during 1987 indicating a cycle of 50 years.

Factors Affecting Gregarious Flowering in Bamboo

Observations taken in the Shahdol area indicate that the following factors affect the intensity of gregarious flowering (Dwivedi, 1988),

(i) **Age of the Crop:** It is often believed that the period of gregarious flowering depends upon the age of the clump. Only those clumps which have attained the age of physiological maturity flower and subsequently die. In natural forests of bamboo which are worked under a selection system, it would be wrong to presume that most of the clumps are of the same age. In good forests, there will be a continuous formation of clumps and clumps of all age classes would be present as sufficient seeds are available from sporadic flowering. If that is the case then only those clumps which have reached the age of physiological maturity should flower and die and gregarious flowering should affect only a small proportion of the clump population.

(ii) **Site Quality:** Observations in Shahdol circle indicate that site quality has a considerable effect on bamboo flowering. In the same area, good sites tended to delay and decrease the extent of gregarious flowering.

(iii) **Management Practices:** In areas where clumps are properly worked, the proportion of flowered clumps is comparatively less than in areas with unworked and congested clumps.

(iv) **Biotic Interferences:** Biotic interferences such as grazing as also the incidence of fire increase the intensity of gregarious flowering. The bamboo forests located near villages have a greater flowering intensity, whereas those located in comparatively protected areas away from habitation flowered partially. The areas with heavy biotic interference coupled with poor site quality had almost 100 percent flowering. This may be due to the fact that areas subjected to heavy biotic pressure did not have younger clumps.

Ecological impacts of bamboo flowering

(i) **Impacts on vegetation:** After flowering the bamboo clumps dry up and die and become inflammable in the hot season, when accidental fires may take a heavy toll which could results into disappearance of valuable wild flora and fauna. This period is very critical for the regeneration of bamboo seedlings as well as for advance growth of the tree species in the over wood.

The gregarious flowering and drying of bamboo may also results into bare grounds and expose the soils in the bamboo-dominated areas, which may increase soil erosion. Thus, due to various factors that are operating in the bamboo forests during mass flowering, significant changes occur in the structure and composition of ecosystem of the areas. Forest fire and other ecological changes may results into population level changes and some valuable species may also be lost. Since the bamboo plants die after flowering, it will be at least some years before bamboo plants grow again from seed, leaving bare exposed soil, which could be disastrous in the mountainous region of Mizoram.

(ii) **Habitat disturbances:** Disturbances of suitable habitats due to bamboo flowering may result into reduced population of *Wild fauna*. Different species of wild animals are decreasing gradually as a result of disturbances of the ecological balances in the area.

Destruction and disturbances of their habitats has checked the reproduction, growth and multiplication of animal and birds. There has been a severe reduction in both the range and the population due to habitat lost as a result of agriculture and industrial development, construction of human settlements, practice of shifting cultivation and forest fire. Since, habitat requirements of most animals are quite narrow, with the lost of suitable habitats populations are destroyed eventually leading to extinction of species. A study made by Rastogi and Rastogi(2002) showed that recent extinction rates are 100 to 1000 times their pre-human levels in taxonomically diverse groups from widely different environment.

(iii) **Environmental impacts:** The gregarious flowering and drying of bamboo is thought to have significant impacts on environment although no assessment is made on its impacts on the various environmental factors viz. air temperature, rainfall, humidity, soil status etc. Since, bamboos keep the environment clean and cool by absorbing significant amount of Carbon dioxide and other gases the mass drying of bamboo forest may cause significant changes in the micro-climate of the affected areas through reduced rate of Carbon Sequestration. It was reported that during the bamboo flowering in Mizoram in the late 1950s, there was a sharp rise in temperature followed by a spell of dry arid weather. When the bamboo clumps dry up and become inflammable in the hot season, the intensity of forest fires may be increased which could results into the release of higher quantity of smokes into the atmosphere thereby increasing air pollution. Further, with the released of the higher quantity of smokes and other gaseous particles, there could be a significant increase in temperature of Mizoram and the neighbouring states.

Conclusion

Bamboo forest covers 29.02% of the total geographical area of Mizoram and it is expected that an area of 6,118 Sq. Km. will be covered by the gregarious bamboo flowering which have significant impacts on the environment. However, no record of systematic study and impact assessment is available since gregarious bamboo flowering occurs at a long interval. Thus, it is high time to alert environmentalists and the concerned department/ organization to make impact assessment of gregarious bamboo flowering in the north eastern India.

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POPULATION DYNAMICS OF RATS IN RELATION WITH BAMBOO FLOWERING

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Abstract

The class Mammalia could be said as entirely dominated by rodents in terms of abundance, adaptability, and ecological impacts. In spite of only a minor fraction of the group (<10%) being pests in human environments, the extent to which they cause destruction is beyond comparison. They remain the leading factors in agricultural damage and spreading major epidemics. These attributes can largely be due to their innate ability to profusely reproduce when suitable conditions arise. Field and experimental trials have ascertained social and physical constraints including food limitation, predation, and cannibalism as the driving factors to their otherwise steady population growth. With occurrence of sudden natural anomalies such as high precipitation, El Niño Southern Oscillation (ENSO) phenomena, and high crop yields, which operate in link with one way or another, the maximal procreation and survival in rodent population often result. Profuse seeding of forest trees in central Europe, North America, and New Zealand also provide suitable food resources for such population fluctuation. Thus their characteristic numerical fluctuations have earned them the principal models in population dynamics. However the intrinsic mechanisms underlying the role of various factors are yet incompletely defined. In particular the plausibility of masting, especially of bamboo, in driving rodent irruptions has not been properly established. One line of reasoning points to the historical claims without standard tests or data that rodent outbreaks are directly influenced by masting; while the other with experimental evidences strongly evicted the case of bamboo flowering as the direct cause. One of the most famous bamboo mastings is that of *Melocanna baccifera*, most experienced in Mizoram and often associated with historical records of horrendous famines inflicted by rodent population explosions. The flowering and fruiting of *Melocanna* is generally accused of as the main reason for the rodent irruptions. However fragments of historical sources expound the coincidence of other factor such as rainfall and rice production. As commonly observed in other parts of the world, precaution has to be taken to vindicate any factor that may affect rodent population dynamics that generally varies from a particular region to another.

Introduction

A very long, long time ago, once upon a Cretaceous Period, nature saw the emergence of a novel group of teeming, scurrying, nibbling, gnawing, whisker-quivering, petite animals. 75 million years ago, the Cretaceous world would have been a perfectly ideal place to live in. As a consequence of the Great Cretaceous Catastrophe most large animals were wiped out, of which the most legendary group being the awesome dinosaurs. With all your adversity, you would not have to worry about phone bills, tax inflation, traffic jams, the vice of politics, social dilemmas, and domestic chores, if you happen to be there. In fact there was not a soul of humankind back then, after all you would be an incongruously odd one, for one superpower dominated the world, not the United States, but the rodents, rats and the likes.

Perhaps rodents present a story of being the most successful mammals – a class of animals to which you and I also happen to be bona fide members. "Rodent" implies a generalized term for the members of the order Rodentia under the class Mammalia, of which rats (*Rattus* and *Bandicota*) and mouse (*Mus*) would be the most familiar, constituting the three major genera of rodent pests in Asia, and in out present context too. There are more than 2,700 species of rodents worldwide, are by far the largest order of mammals. More than 42% of all the described mammal species on earth are rodents, and there are said to be more individual rodents in the world than all other mammals taken together. *Rattus* alone, with at least 61 valid species, is not only the single largest mammalian genus of all, but also arguably among the most complex and least well understood. Two-thirds of living rodent species belong to just one family, the Muridae, and most of the rodents found in Asia, both pests and non-pests, also belong to this family (Aplin et al., 2003a,b). But still hardly 5-10% of them are actually pests, causing much concern – emphatically a grave concern.

Rodents are the most important group of mammals in terms of species number, abundance, scope of distribution and their impact on the livelihoods of people. They have been the hidden beneficiaries of our own Agricultural Revolution, and they have travelled with us across the seas to every land in the world. They are completely inconsiderate about such blatant axiom as, "Sow shall you reap." On the contrary, they reap what they never had an intention of sowing, harvesting and devastating our hard-laboured crops and vegetation. They voraciously devour those that are dearly and wearily toiled by human perseverance from foodstuffs to clothing to household materials. They never lost their stronghold record of being an unsurpassed number one factor constraining food production. For any cause, rodents are genuine menace to our food stores, and as the inevitable aftermath of their outbreaks, famine is the writing on the wall.

Yes, they do more harm than can be possibly appreciated. They are not only the perfect exterminator of our agricultural products, but also one of the most debilitating threats to our health and those of our livestock. Them and their cargo of fleas were responsible for the Black Death; as a matter of fact, occasional great plagues are the irrevocable hallmarks in the history of mankind. They have successfully spread death-tolling typhus and plagues, and have been aptly blamed for more human deaths in the second millennium than all wars and revolutions, bird flu, SARS, and AIDS put together. It is notoriously hard to count the blessing they have endowed upon us. Of their indomitable superiority, who better captivatingly than Robert Browning had depicted:

Rats!
They fought the dogs and killed the cats,
And bit the babies in the cradles,
And ate the cheeses out of the vats,
And licked the soup from the cook's own ladles,
Split open the kegs of salted sprats,
Made nests inside men's Sunday hats,
And even spoiled the women's chats,
By drowning their speaking
With shrieking and squeaking
In fifty different sharps and flats.

(*The Pied Piper of Hamelin*, 1888)

On the other hand, a world without rodents would be a very different one. It is less likely to come to pass than a world dominated by rodents and free of people. Richard Dawkins (*The Ancestor's Tale*, 2004, p. 182) may not be far from the truth in conjecturing that if nuclear weapons – the product of our intelligence – are foolishly deployed for the destruction of mankind and most of the rest of life, a good bet for survival is rats. When even the four horsemen are laid low by the apocalypse, it will be rats that scavenge their remains, rats that will swarm like bees over the ruins of civilization. The meek by then may not have a chance to inherit the earth at all. In the post-Armageddon scenario, the world will be again dominated by none other than by the rodents, presumably much more powerful than their Cretaceous ancestors. This is exactly why they apparently are and would be the most successful mammals -- their uniquely unrivalled adaptability.

Despite their undisputed success, their extensive adaptability, and their historical use in scientific studies, rodents in general and rats in particular have consistently been given bad press. As destroyers of crops, as vectors for disease, and as pests in house and field alike, they have been shunned. But it is for such an amazing intimacy they bear with us that only after to us (as a legitimate biological species), rodents are unarguably the most exhaustively studied life form of all time of any kind. With a comprehensive genomes of the mouse, *Mus musculus* (Waterson et al., 2002) and the Brown Norway rat, *Rattus norvegicus* (Gibbs et al., 2004) now at our disposal they justly remain a favourite main staple group for both ecological and behavioural studies, appropriately a sole mammalian model in experimental researches, and the background of literature now available in these scientific disciplines would fill a good library.

Rodent Ecology and its Impacts

Rodents are the masters of colonizers, impertinent accomplice of human habitations, to be found every four corners of the earth. Their adaptability to varying environments is overwhelming, occupying a wide range of natural habitats, including forests and grasslands, as well as the human world of agricultural landscapes, villages, houses and drains. They continue to be the enduring neighbours of human cultures with all our sophistication, the unsolicited lingering guests in every nook and cranny of our civilised world.

Ecologically speaking, most rodents are prolific breeders and they often represent a significant amount of the animal biomass in natural ecosystems. As such, they play an important role in the food web, both as consumers of plants and fungi, and as a food resource for many of the larger predators. Rodents are largely herbivorous and their great abundance in most of the world's ecosystems creates a broad layer of primary consumers in the pyramid of numbers. They are also important environmental engineers, helping to spread pollen and seed, aerating the soil through their digging and burrowing activities, and in extreme cases (e.g. beavers), changing the whole nature of the landscape. And, of course, as secondary consumers they form the prey base for a very wide variety of consumers, including snakes, raptors, owls, and small carnivores. The taxonomic and number dominance of these small mammals show quite clearly that the pros clearly outweigh the cons of being small.

Rodents cause major losses to agricultural production, despite the availability of very effective rodenticides and other techniques to kill rodents. Estimates of damage vary widely: for a country like Tanzania, the average annual yield loss of maize is 5–15%. This corresponds to more than 400,000 tonnes of maize, equivalent to an amount that could feed 2.3 million people for a whole year, representing a financial loss of around US$40 million

(Food and Agriculture Organization of the United Nations (FAO) 1998 data). In Indonesia, rodents caused-annual losses in rice production lie between 10-20%, in Malaysia 2-5% (Singleton et al. 1999), in Thailand 6-7% (Boonsong et al. 1999), in India and Bangladesh 5-10% (Parshad 1999; Aplin et al., 2003), in Vietnam 20-30% (Singleton et al. 2003), and in Pakistan 17-23% (Lathya et al., 2003). Even when using a conservative estimate of 5% for the whole of Asia alone, an annual loss of rice due to rodents amount to tens of million tonnes, enough to feed about 200 million people.

country	rodent species	No of that damage crop	No of species in cropping systems	Conservation status	
				species at risk	Little known
Africa	381	77	12-20	60	11
Australia	67	7	4	14	1
Europe	61	16	5	4	
India	128	18	12	21	1
Indonesia	164	25+	13	11+	28+
Laos	53	12+	4-8	4	14+
New Guinea	73	10+	6	0	9+

Table 1. The number of species belonging to the Order Rodentia in various geographical regions that are considered significant pests of agriculture, and those whose conservation status is of concern (endangered, critical or vulnerable) or insufficient is known to assess the risk. (Based on Singleton et al., 2003)

Most of the pest species are closely associated with human activities, hence generally termed commensal rodents. The most widely encountered species of rats and mice are often the local residents of granaries. Infamous in India is *Bandicota bengalensis* commonly found in both villages and towns, and in associated cropping areas. It is usually most abundant in higher rainfall areas, there are few estimates of population density, but one study in Andra Pradesh, gave figures of 0.5-2.4 individuals/ha (Prakash, 1998). Very high populations have been recorded in urban grain stores ('godowns') in India. This species takes a wide range of food items, including molluscs and crabs. However, in feeding trials, it prefers cereal grain to animal foods, and rice over wheat. Being a good swimmer, it causes significant damage to deep-water rice crops.

Eighteen species of rodents are pests in agriculture, horticulture, forestry, animal and human dwellings and rural and urban storage facilities in India. Analysis of the information available on the damage and economic losses caused by rodents in rice, wheat, sugarcane, maize, pearl millet, sorghum, oil seed, legume and vegetable crop fields, horticulture and forestry, poultry farms, and rural and urban dwellings and storage facilities clearly shows that chronic damage ranging from 2% to 15% persists throughout the country and severe damage, sometimes even up to 100% loss of the field crop, is not rare (Parshad, 1999).

Rodents show tremendous resilience in adapting to adverse conditions. Denudation of natural habitats has sure endangered many species but rodents show just a reversal of trends. Their numbers multiply with destruction of wild habitats or in areas that have sparse vegetation. A study conducted by Ishwar Prakash and his colleagues in 1993-94 in the Abu hills of the Aravalli ranges lend support to the fact. There is more species richness and abundance in the rocky habitats with sparse vegetation as compared to hills with dense vegetation. Another study in 1998 in denuded hilly grasslands of Dungarpur in Madhya Pradesh also revealed that the rodent population is rich with many species and relatively high than they had been earlier when dense forests covered the region. Further support to the fact is lend by the results from the study in Andhra Pradesh which had shown that after cyclones the rodent population increased to four times the original population in fallow lands as compared to two times in agricultural fields (CSE, 2006).

Flood waters logging in fields and other areas compel the residing wild rodent population to seek upper reaches, usually near human habitation that increases their interaction with domestic rodents facilitating flea transfer from the reservoir population to the domestic ones. Three independent studies showed however that during floods in countries like Bangladesh, Myanmar, Malaysia, Indonesia a temporary migration of rodent pests occurred to higher fields while some species also showed adaptation to water logged fields (Prakash, 1998). So instead of perishing in such harsh environments, these adaptive rodents survive in flooded conditions.

Of Plagues and Diseases

The tenth and the last plague of Exodus was a spine-chilling holocaust, annihilating all the first born of Egypt in a single sweep; even God assured that there shall be a great cry, such as was not like it before, nor shall be like it again. The Bible is wrong in the sense that it is a mere laugh, though there is obviously nothing to be happy about. The plague in India in the early 20th century CE alone claimed 12.5 million human lives, the number apparently much more than the ancient Egypt population. However, in comparison to the total population affected, the Indian statistics is still laughable, when the infamous Black Death of 1346-1353 slaughtered more than 60 percent of Europe's population with its first strike alone. It still holds a record of being the most devastating plague of all time. The cry in Egypt would have been a whimper.

These historically and scientifically documented plagues were caused, gracefully not by the wrath of God, but by a bacterium, *Yersina Pestis*, which is transmitted by a rat-flea (*Xenopsylla cheopis*) bite to humans. If there were anyone's wrath, it would be of the rodents. Rodents, particularly *Rattus rattus*, are the devoted messengers in these episodes. It is remarkable that the most common flea on each species of rodents often differs: *Nosopsyllus fasciatus* dominated on ship rats, *Pygiopsvlla hoplia* on Norway rats, and *Leptopsyllus segnis* on mice. However a particular species is the potential carrier of any other or all of the fleas (Innes et al., 2001). The fleas with which they are so intimately associated are the actual hosts of the bacterium. If plagues were sent through rats instead of a series of frogs, lice, flies, and locusts, God could have more impressively and persuasively smitten the vulnerable Egyptians, if only he had known!

There are three types of plagues. Bubonic plague is seen after 2-6 days after the bite of a rat flea the patient gets a sudden onset of fever, chills and headache. A swelling (or bubo) develops in the lymph node around the groin or neck region within 24 hrs. Pneumonic plague is the most feared complications of bubonic plague. It is a contagious infection, which reaches the lungs as the bacteria are transmitted from the bubo to the lungs through blood, which spreads through cough droplets in the air. Septicaemic plague is caused by the rapid multiplication of the plague bacteria in blood causing fever and death. Bubonic plague is generally thought of as a historical disease; however, it is still responsible for around 1000-3000 deaths each year worldwide (Keeling and Giligan, 2000).

With regard to the kinds, plague is hardly a tip of an iceberg that the committed rodents are pathologically the dreadful messengers for. In terms of diseases and death toll rodents are by far the most obligatory foundation in shaping the course of human history. They are known to serve as hosts for at least 60 zoonotic diseases. Many of the clinically significant zoonoses are successfully carried by commensal *Rattus* species. Examples include tick typhus, scrub typhus, murine typhus (rickettsial disease), salmonellosis, toxoplasmosis, various spirochetal diseases (e.g. Lyme disease, leptospirosis) and some protozoal diseases (e.g. leishmaniasis, toxoplasmosis). Of these, leptospirosis is of special concern as an emergent infectious disease, with a recent upsurge in the rate of diagnosis of this previously 'hidden' disease. In addition, new rodent-borne zoonoses are identified on a regular basis. For example, between 1995 and 1999, more than 25 new hantaviruses and arenaviruses were identified in rodents (Aplin et al., 2003a).

Hantavirus infections are also of particular concern because of the high mortality rates (5-35%) associated with several of the 10 or so recorded viruses of this group. An instant worth mentioning with all its scientific miscarriages is the hantavirus outbreak in North America, as recent as in 1993. An unusually heavy rains and snows in the spring of 1993 brought about drastic population dynamics. These climatic conditions led to both an abundance of pinon (pine) nuts and grasshoppers, which mice eat, and a coincident reduction in the numbers of predators of mice – foxes, snakes, and owls. As the epidemic emerged, there was a 10-fold increase in the usual density of the deer-mouse population (Hughes et al., 1993). Rodents are the abode of the deadly hantavirus. For this particular hantavirus epidemic was blame the deer mouse (*Peromyscus maniculatus*), and indeed was found guilty of charges (Stone, 1993). The consequent was an indifferent daily massacre of the innocent citizens.

Reproductive Biology

An important book is published by Australian Centre for International Agricultural Research that encompasses all the major research works on well-known rodents in south east Asia (Aplin et al., 2003a, pp. 121-223), in light of their research it is possible to comprehend the breeding habits of the most commonly encountered species. Let us be judicious for the more relevant ones from our own perspective in terms of relevance and occurrence, based on the ample lights thrown by Rokhuma (1988), Singh et al. (1994), and Chauhan (2003).

Of all the rodents found in Mizoram, *Bandicota indica* (commonly a giant bandicoot), which I dare identify as "Zuchang" according to the native Mizo, is probably by far the most abundant species during the great famines (Ṭampui) caused by rodents. Sahu and Maiti (1978) had elaborately described the reproductive behaviour. Generally the breeding activity in rural populations is seasonal, with peak activity coinciding with crop maturation. In urban grain stores in India, breeding occurs year-round but with a peak in the dry season. Pregnancy rates in these contexts peak at 50% in October-April but fall to 27% during the middle of the wet season (May- September). The estrous cycle is 4-8 days and the gestation period is 23±1.2 days. Sexual activity commences as early as three months of age among females and slightly later among males. In an urban Indian population, sperm production began around days after birth. Reports of litter size range from 1-9, up to with means of 6.2 in the Punjab, 8 in Bombay, and 7 in Yangon. The average interval between pregnancies ranges from 30-60 days, and average life span in a Kolkata godown is ~200 days and only 3% of individuals live for longer than one year. The pregnancy rate in this population fell to 2-15% during periods of food shortage but rose to a maximum of 44% around rice harvest time. The estimated number of young produced per female is 28.2 each year.

Second is a large group of mice, probably "Nawizel" and "Zu-te" being the members, and can be widely classified as *Mus musculus*. This species complex has a similar reproductive pattern to other rats, slightly shorter in duration for the different behaviour, such as a gestation period of 18-21 days. Female breeding activity usually commences at around 45 days. Breeding is seasonal in arid environment but al year round in wetlands (Rao, 1992). The usual breeding season is between spring and autumn, but breeding can ensue in continuous abundance of food (Ruscoe, 2001; Ruscoe et al., 2003). Litter size ranges from 5-7 g and the median weight or reproductively mature female is 18 g.

The third comprises two but closely related species of *Rattus*, the variously named ship/black/roof rat, *R. rattus*, apparently "Tampui" and the Himalayan rat, *R. nitidus*, ostensibly "Zuhrei". These two comprise the fiercest rodents in agriculture in the events of outbreaks in Mizoram. The breeding biology of both is also very similar. Year-round breeding is likely in warmer regions, provided adequate food is available. Mean litter size is 8.1 with a wide rang from 4-15. Captive females of *R. nitidus* can produce four litters per year with an interval between births of 37±10 days. Most wild-caught pregnant females have only one set of scars, indicating a lower reproductive output under natural conditions. Male rats showed signs of delayed sexual maturation and females, though fertile, did not bear litters until relatively late in life (> 300 g) (Butler and Whelan, 1994).

Urban or village populations of *R. rattus* generally breed more-or-less year-round, probably feeding on refuse and stored food. However, populations living in field habitat generally show cycles of breeding activity and population abundance linked specifically to cropping cycles. Thus in the field breeding activity is closely linked to the growth and maturation of rice crops, with first mating taking place just before maximum tillering. Females show faster sexual maturation than *Bandicota* and *Mus*. Males appear to mature somewhat later. The gestation period is 21±1 days, with an estrous cycle of 4±1 and litter size in wild-caught samples ranges from 5-12, but can be as high as 14 in exceptional circumstances. The interval between births in captive animals is usually 20-25 days (Tristiani and Murakami, 1998). The average number of litters per female per year is 8 and mean number of young per female per year is 58. Very high adult female pregnancy rates, close to 100% have been recorded in West Java. This together with the high litter size may also explain the very high seasonal abundances of this species (Lam, 1983).

Diet, Sex and Number

Diet is another aspect in which rodent species show considerable diversity. Though most are basically herbivores, many rodent pests are opportunistic omnivores. Their eating capacity normally reaches about 10-15% of their body weight daily and waste 7.5 times the amount they consume. They can live on a variety of foodstuffs (green plant materials, seeds, fruits, or insects) and thus survive in many different types of crops, but they can also take advantage of a single food item like the grain seed, and can become available in large amounts (e.g. multimammate mice, *Mastomys natalensis* in Africa or house mice in Australia). However, this is not a general feature: other species, like the rice-field rat, *Rattus argentiventer*, have more specialised dietary requirements and thrive only in grasslands such as rice fields. Dietary variation means that some rodent species will be very sensitive to changes in crop choices, land use and field management, while others will be affected only marginally (Leirs, 2003).

Limiting food resources has been widely accepted as one of the most important factors affecting life history strategies. Neurological experimentations have also provided a vivid understanding of the hormonal basis of reproductive inhibition in vertebrates including mammals. Food restriction is well established to cause impairment of the hormonal system that regulates the normal cycles of breeding, particularly in female rodents, and these impairments can be rapidly reversed by acute re-feeding (Temple and Rissman, 2000). Postnatal undernutrition has been found to show transient influence on follicle growth and development in females. In male rats, onset of puberty is delayed and testicular function is also impaired, associated with decreased testosterone levels (van Weissenbruch et al., 2005). An early malnutrition during different critical developmental time windows can result in different long-lasting effects on pubertal development.

The relationship between food resources and reproduction has been widely studied in their natural habitats, in particular, positive effects on mice and vole reproduction have been observed. Most experimental studies have examined the effect of food addition on population level (Predavec 2000), with food supplementation advancing the onset of breeding and reproductive success in individual rodents (McAdam and Millar, 1999). Food-driven changes in reproduction, particularly due to low food quality (Singleton et al. 2001), are regarded as an important factor driving changes in house mouse numbers producing irregular outbreaks of mice in the grain-growing region of southeastern Australia. As a routine population outbreaks are followed by a collapse in population numbers and low numbers for several years thereafter.

However a single prominent factor does not always form the basis of reproductive behaviour. A large-scale food manipulation was conducted in Australian farms in which food quality had no empirical factor as the driving factor for improved reproduction and formation of an outbreak of mice (Ylönen et al., 2003). Reproductive traits in rodents are the products of a number of environmental, social and chemosensory factors, e.g. the nutritional status of females will influence ovulation rate and litter size, as will exposure of females to other rodents of various social statuses. Outstanding observations were obtained from Whitten (1956) and Bruce (1959) on the synchronisation of ovulation and pregnancy block in rodents (Voznessenskaya et al., 2003), now known to be pheromonal effects called 'Whitten Efftect' and 'Bruce Effect,' respectively.

Energy intake is known to affect the onset of puberty in mammals; for example, pigs and rats with inadequate nutrition have retarded sexual development. Thus the choice of diet may influence the timing of sexual development (Odum et al., 2001). Higher levels of phytoestrogens in standard feed are estrogenic to rodents, causing effects such as increased uterine weight and advanced vaginal opening (VO) in immature animals, similar to effects observed with xenobiotic estrogens (Tinwell et al., 1999). Experiments have concluded the existence of an effective dietary mechanism that enables a social rat species to tolerate each other in dense feeding aggregations when food is abundant. When food is limited, social intolerance including cannibalism increases and causing reduction or impediment in population growth (Lore et al., 2006).

Protein is responsible for efficient reproduction, growth and development, quality of the mother and the litters. But there is still a veritable limitation. A threshold amount is always required in natural systems, so do in the rodents. The reproductive response of two rodents *Mastomys coucha* and *M. natalensis* mothers to variation in dietary protein intake has been substantiated. Successful breeding occurs only on optimal protein diet, i.e, 6%, while at successive higher concentration, reproductive output inversely deteriorated (Jackson and Van Aarde, 2004). In *Mus*, the protein demand is much higher, data analyses concluded that12-14% of "good quality protein" is adequate for mouse growth, and 17-19% is adequate for reproduction (Knapka, 1983). In case of human adults and rats, the intake required to maintain a stable nitrogen balance and protein turnover has been decisively established at 10-15% of total energy, and a high protein intake is often considered an unnecessary burden, particularly for the liver and kidneys (Dunger et al., 1997).

Rats that are allowed to select their diets often ingest >30% of their daily energy in the form of protein. Such an intake may seem unhealthy, but the consistency of this choice suggests that it is motivated by physiologic drives, and they are able to regulate their daily energy intake, body weight gain, and reproductive cycle. Several studies have shown that protein intake is tightly controlled. In particular, compared with carbohydrate-restricted rats that do not develop an appetite for carbohydrate, those that have been protein restricted do increase their protein intake when protein is made available (White et al., 2000).

During times of food depletion, an individual can determine the survival of a population such that scarcity will prompt the potential individuals to respond to the adversity by reducing energy output related to reproduction. However, reduced reproduction may be beneficial while complete reproductive inhibition may not be adaptive. Reduced procreation would relieve energetic constraints on lactating females that might otherwise jeopardize survival if a full litter size were attempted (Voznessenskaya et al., 2003). Interestingly pheromonal signals also can directly influence the reproductive activity. Rodents are readily affected by the presence of their predators; their sexual activity can be greatly reduced, including extended estrous cycle in females. Rats, moles and mice are shown to respond to chemical cues of different origin in the similar manner: reducing numbers of cycling animals and lowering the probability of pregnancy, when they are subjected to predators (Feoktistova et al., 2003).

Prerequisites for an abrupt population increase seem to be an early onset of breeding and an extended breeding season. It must be borne in mind that albeit generally conceived limiting food resources as one of the most important factors affecting life history, the availability and quality of food are not necessarily the main factors in rodent population dynamics. Field experimental analyses have demonstrated no consistent evidence that food quantity leads to peaks in population density (Bomford and Redhead, 1987; Innes et al., 2001; Ylönen et al., 2003). Significant increases were related to densities of transients and juvenile individuals (Castellarini and Polop, 2002). In fact the most parsimonious explanation would be that rodent population is driven not by a single and simple factor, but amalgamation of complex factors including food quality and quantity, seasonal abundance of water (rainfall) that favours the survival of the young ones, and sometimes immigration from exogenous population.

Population Dynamics – Rats, Rice, Rain and the Rest

Regular oscillations of rodents have been a fright to farmers and a fascination to ecologists, and provide a central focus in population dynamics within the Animal Kingdom, due to their extensive multiannual and often more or less cyclic variation in population size. Different patterns of population dynamics are the result of differences in life history and interactions with the environment. Populations of small rodents are indeed likely to be good model systems for studying the seasonal decomposition of the between-year annual variation in the population dynamics. This is so because they invest heavily in procreation by having relatively large litters and sometimes early age at first reproduction, and because they typically have different generations within a year exhibiting markedly different reproductive strategies (Yoccoz et al., 2001; Stenseth et al., 2002b). In highly seasonal environments, a seasonally structured population model seems obvious to improve our understanding of the interface between demography (statistics of population such as birth and death) and the resulting population dynamics. For small rodents, seasonality implies most of all changing between two (seasonally determined) regimes or stages: a reproductive season and nonreproductive season. Both the level of the net population growth rate and the density-dependent structure varies between these two regimes, partly because reproduction typically occurs only in one of the two seasons but also because survival may differ greatly between the two seasons (Lima et al., 2003).

Although there is now some agreement that the interaction with certain factors is involved, many aspects remain enigmatic, one being the precise ecological mechanism involved in the first-order feedback effect (i.e. direct density dependence). The population abundance of any individual species is determined by the numbers of births and deaths in a given area, and by the number of animals moving into (immigration) and out of (emigration) that area (see Fig. 1). Each of these factors may be influenced by seasonal or longer-term climatic cycles, fluctuations in the abundance of food or predators, or changes in land-use patterns. The population abundance of other species that compete for food or space may also be important. Apparently rodents regularly move from habitats where they are confronted with reduced water and food supplies in the hot dry season to habitats with abundant either temporary or permanent supplies. However, there are many exceptions to this rule related to various adaptive behaviours triggered when rodents are driven from their habitat by natural (floods) or anthropic (slash-and-burn farming, brushwood clearance, crop planting, etc.) disruptions and highlight the wide variability in population densities during the period after the disruption (Papillon et al., 2006).

Only a relatively small number of processes can significantly influence the population dynamics of a species in a given area, and chief among these are temporal variation in rates of migration, mortality and reproduction (Fig. 1). There are well-established documentations of seasonal variation in fertility and fecundity in rodent populations of Australia. A long-term study from 1982-2000 firmly convinced a cyclic normal pattern of high litter size in spring and decreasing litter size towards the end of summer in *Mus domesticus* (Singleton et al., 2001). A complex intertwining of factors is also represented by the demography of water pythons (*Liasis fuscus*) and their main prey, the dusky rat (*Rattus colletti*), on the Adelaide River flood plain in tropical Australia. The link between annual rainfall patterns and rat demography was highly non-linear. Rat numbers were low during years with low and high rainfall at the end of the wet season (April) presenting an unusually clear and direct link between an abiotic factor (rainfall) and predator-prey population dynamics (Madsen et al., 2006).

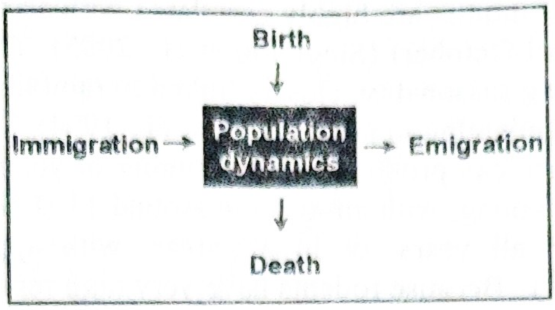

Fig. 1. The stability and fluctuations of a population are basically maintained through these for processes.

In addition, the social structure might differ profoundly between seasons – differences that typically affect the density-dependent structures in different seasons. Differences in the seasonal structure of the vital rates may indeed represent the phenomenological causes for differences in population dynamics (Stenseth et al., 1998, 2002). Regular oscillations of northern small rodents (lemmings, voles and mice) have been observed for decades. In particular, cycles exhibited by Fennoscandian voles have inspired population ecologists to propose several hypotheses for their underlying causes. These rodent populations are basically regulated by both highly consistent first-order feedback (e.g. intra-specific competition, functional responses of generalist predators) and less consistent, site-specific second-order effects (e.g. numerical responses of specialist predators or food plants) (Lima et al., 2006a,b).

Well-known examples of high-amplitude, large-scale fluctuations of small-mammal populations include vole cycles in the boreal zone of Eurasia, lemming cycles in the high-arctic tundra of Eurasia and North America, snowshoe hare cycles in the boreal zone of North America, and outbreaks of house mice in southeastern Australia (Stenseth et al., 2002; Korpimäki et al., 2004; Lima et al., 2006a,b). Survival rather than reproductive rate appears to drive rates of population increase during these fluctuations – the rate of reproduction which is often constrained by availability of nutrient rich food. Food limitation may stop increases of cyclic vole, lemming, and hare populations, whereas the decline from peak numbers is caused by predation mortality. In house mice, without coevolved predators, outbreaks may be driven by rainfall, food supply, and disease (Korpimäki et al., 2004).

A general finding of studies on the effects of climate on the dynamics of animal populations is that climate can have complex (e.g. non-linear and/or non-additive) effects on the endogenous feedback structures regulating population dynamics (Lima et al., 1999, 2002, 2006b; Stenseth et al., 2002). Periods of unusually high rainfall presumably favours increased production in the quantity of food available to rodents or its quality, such that relationships between the likelihood of an outbreak and past rainfall form the basis of an outbreak forecasting method. A five-year mark-recapture study of dusky rats on the Adelaide River floodplain, revealed substantial annual variation in the intensity and timing of monsoon rainfall during the 'wet-season' is the main factor driving the demography of the rats (Madsen and Shine, 1999). When total rainfall figures are modified to reflect the magnitude and duration of inundation of the floodplain each year, a link is evident between rainfall patterns and the rat population dynamics. Minor spatial variations in elevation (and hence, in the duration of inundation) across the floodplain engender large differences in rat growth rates, condition factors, survival rates, and the duration of reproductive activity each year. Irregular outbreaks of house mice in the wheat-growing areas of south-eastern Australia are also positively driven by weather variability, particularly rainfall. Rates of increase of populations over spring and summer are highly correlated with accumulated rainfall from the previous winter-spring (April-October) (Singleton et al., 2005). The African multimammate mouse shows a strict breeding seasonality, closely linked to rainfall periods, probably through the stimulating effect of germinating grasses (Leirs et al., 1994). This induces maturation of sub-adult females, which then can produce a large number of young in a short period due to the high litter size up to 24 young, with an average around 11 (Leirs et al., 1997). However, outbreaks do not occur in all years, or in all areas, with apparently suitable climatic conditions (Pech et al., 2003). Because rodents have very high reproductive rates, small rain-induced differences in the duration of their reproductive season (i.e. number of litters per year) can cause massive differences in subsequent rat abundances. Hence, rodent numbers can be predicted from rainfall patterns during the preceding wet-season.

One of the most dramatic examples of climatic influence is given by numerical fluctuations exhibited by small rodents inhabiting arid and semi-arid ecosystems of South America. In arid environment water is the prime limiting resource. After events of unusual high rainfall there is a subsequent chains of increases in primary productivity, plant cover, seeds and small rodents. Evidence of the influence of is clearly noted in northern Chile, where the pulses of productivity in ephemeral cover and seed are driven by unusual rainfall years, closely related to El Niño Southern Oscillation (ENSO) climatic phenomena (Lima et al., 1999b). ENSO is a climatic and oceanographic phenomenon noted for its profound effect on terrestrial ecosystem, a recurring theme was the strong increase in rainfall associated with ENSO events in dry ecosystems (during the El Niño phase of the oscillation in the Americas and the La Niña phase in Australia). As a routine unusually high precipitation ensues ENSO, and a concurrent of rodent outbreaks are closely associated in almost all the recorded events (Lima and Jaksic, 2004). In consequence, certain small mammals are noted to show striking population irruptions following such climatic uprisings. Several long-term studies show that a pulse in primary productivity causes a subsequent increase in herbivores, followed by an increase in carnivores, with consequences for changes in ecosystem structure and functioning that can be quite complex. These climatic events are attributed to 96% of the variation in annual per capita population growth rates of rice field rats (Murúa et al., 2003). It implies that these rodents are strongly regulated by food availability, and rainfall thus presents a proxy for food abundance (Krebs et al., 2004; Lima, 2005).

Food availability is perhaps the most well established primary causal factor for rodent population oscillations. Seasonal crop productions are clearly correlated with the corresponding population rise of the predator rodents. Rodent populations are known to fluctuate greatly throughout the year depending on the growth stages of the rice plants. In Vietnam mixed farming systems, the abundance of rodents (*R. argentiventer* and *R. losea*) fluctuated annually, with a main peak following the spring rice crop, and a secondary peak following the summer rice crop. There is a strong relationship between the monthly abundance of rats and rainfall, but a weak relationship between monthly rates of increase and rainfall (Brown et al., 2005). The peaks in abundance of rodents coincided with harvesting of the spring and summer rice crops. The abundance of rodents was low during the winter season when little or no breeding occurred. Moreover the quantity of rice does not alone affect the predator population, but the quality of the food itself is clearly a prerequisite to have any profound effect. The density of the rice field rats population increased following periods when high-quality rice plants were available, and decreased following periods when only low-quality rice plants were available (Tristiani and Murakami, 2003).

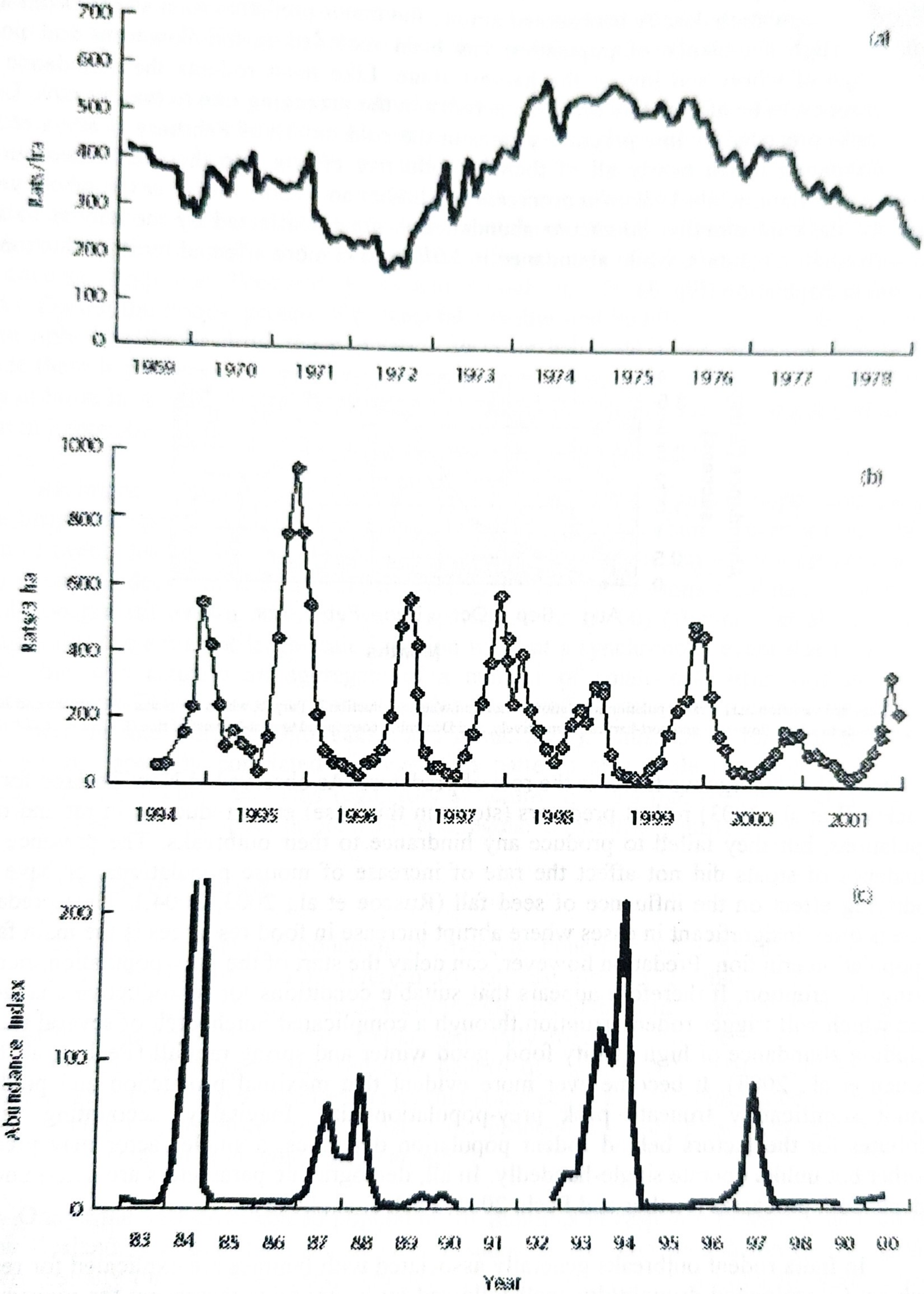

Fig. 2. Multi-year population dynamics patterns in three different agricultural rodent pests: (a) wood rats, *Rattus tiomanicus*, in oil palm plantations in Malaysia, population size estimates (redrawn from Wood 1984); (b) multimammate mice, *Mastomys natalensis*, in a maize fields–fallow land mosaic in Tanzania, population size estimates based on robust design capture–mark–recapture (CMR) analysis (own data); (c) house mice, *Mus domesticus*, in cereal fields in Australia, abundance index based on adjusted trapping success (adapted from Singleton et al. 2001).

The pest population of other cereal crops also exhibit comparable pattern. In wheat fields, cyclic population density is observed among the major predators such as *Millardia* and *Bandicota*. High abundance of population has been recorded at the flowering and post-harvest stage of wheat and low at the harvest stage. Like most rodents the abundance of *Millardia* seems to be affected by breeding activity in the preceding one to two months. Low abundance is preceded by low pregnancy rates in the cold month of February (Lathya et al., 2003). *Bandicota* invest nearly all of their reproductive efforts into the time when cereal grains are abundant, while *Millardia* procreate at a higher and stable rate over the whole year, except for the cold months. *Bandicota* abundance is greatly affected by movement to and from surrounding habitats, while abundance in *Millardia* is more affected by reproduction of the resident population (Fig. 3).

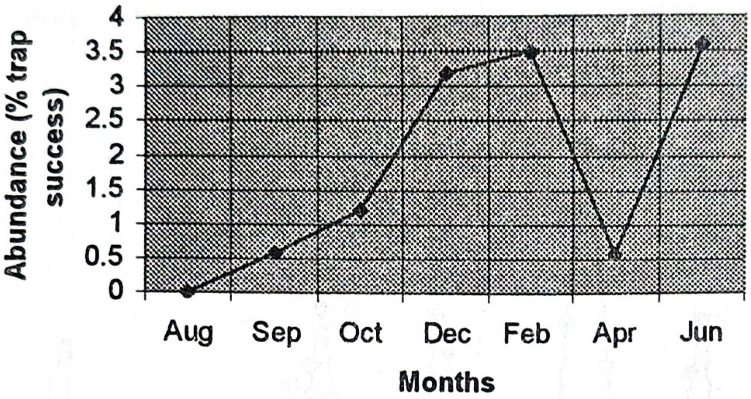

Fig. 3: Seasonal variation in rice rat population in relation to rice and wheat production in Punjab, where the peaks of February and June corresponds to wheat flowering and port-harvest, respectively, and December correspond to post-harvest of rice (Lathya et al. 2003).

One rather ambiguous factor is the role of predators. As observed in New Zealand forests (Blackwell et al., 2003) rodent predators (stoats in this case) exert reduction in rat and mice populations, but they failed to produce any hindrance to their outbreaks. The presence and abundance of stoats did not affect the rate of increase of mouse populations, or have any modifying effect on the influence of seed fall (Ruscoe et al., 2003, 2004;). Thus predation alone is often insignificant in cases where abrupt increase in food resources is the main factor in population eruption. Predation however, can delay the start of the prey-population increase during the eruption. It therefore appears that suitable conditions for reproductive changes in mice which will trigger rodent irruption through a complicated hotchpotch of several factors, including abundance of high quality food, good winter and spring rainfall (Pech et al. 1999; Ylönen et al., 2003). It become ever more evident that maximal production and predators cannot significantly truncate peak prey-population size. Inevitably, accounting various attributes for the factors behind rodent population dynamics, a single factor may preclude another but unlike operate single-handedly. In all, demographic parameters are determined by independent processes (Arthur and Pech, 2003; Pech et al., 2003).

In India rodent outbreaks generally associated with famines are explicated for reasons such as: (i) prolonged drought/dry spell followed by heavy rains increasing the reproductive propensity of the rodent pests, as happened in Saurashtra region of Gujarat state; (ii) failure of the monsoon in the preceding year, resulting in a favourable environment for rodent breeding, as in Cauvery Delta area of Pondicherry and Tamil Nadu states; (iii) flash floods leading to unusual increases in the subsequent carrying capacity of the environment and to the absence of predators in the delta areas, as happens in Andhra Pradesh (East Godavari and

West) and (iv) flowering of species of bamboo (*Melocanna baccifera* and *Bambusa tulda*), leading to increased carrying capacity in jhum1 cultivated fields in Arunachal Pradesh, Manipur, Mizoram and Nagaland states (Chauhan and Saxena, 1985; Rao, 2003).

Natural calamities in general favour the growth of rodent populations as ecological space is created. In Andhra Pradesh, cyclones caused a four-fold increase in the rodent population. Standing crops usually get lodged during the cyclone so that the ear-heads that are more nutritious than the stems or leaves, reach the ground surface and can serve as food for the rodents. Another probable reason behind such unprecedented multiplication of rodents is that competition for food and space decreases for rodents as other inhabitants succumb to the adverse conditions. Frequent floods and drought too favour rodent ecology (Prakash, 1998). During the floods, groups of rodents take shelter and huddle together in dry places. It is not only that floods drive the population to other habitable areas, once the floodwaters recede there is plenty of decaying food and space created by other animals to invade. Heavy rains in Surat in August-September 1994 were possibly responsible for the plague outbreak in Surat in September, the same year (CSE, 2006).

An important message has to be perceived on the nature of rodent population. Large-scale irruptions appear to be not a simple outbreak in a single outburst, rather a mechanistic chain of events leading to a series of local outbreaks. This prediction is demonstrated in the irruption of the deer mouse in Canada where these mouse populations exhibited a domain of population growth over a relatively small spatial extent (<300) (Bowman et al., 2001). It signifies that the apparent large-scale irruption was not a synchronous event due to a single factor, but was actually an aggregate of a number of small-scale irruptions occurring simultaneously. This finding supports the idea that many population processes are local in effect (Krohne and Burgin, 1990; Jaksic and Lima, 2003). Thus, these populations of deer mice are not spatially correlated to vegetation patterns at a scale corresponding to the population growth observed. This regulatory structure suggests that rodent populations are broadly limited by food, space or predators and regulated by intra-specific competition.

Massiveness Due to Masting

Clear supra-annual reproduction in trees is generally with highly variable and synchronized reproduction and is referred to as mast flowering "mast fruiting", "mast seeding" or "masting." The term comes from the Old English word, mæst, for nuts of forest trees that have accumulated on the ground, especially for those used as food for fattening swine. Evolutionarily, a significant selective benefit of masting is "predator satiation." The idea is that large crops satiate seed eaters so that some seeds escape being eaten, particularly in "mast" years with bumper crops. Mast crops produce resource pulses that can broadly affect the local ecosystem in which they happen.

One of the best-documented population fluctuations in response to seed abundance is in New Zealand. The beech forests of New Zealand flower and seed heavily at irregular intervals (usually three to five years). The increase in food supply is a boon for seed eating birds, mice and rats, and their numbers causing their population irruption, which in turn results in prolific breeding of the bird predators, stoats (*Mustela erminea*) (Blackwell et al., 2003). High levels of periodic beech (*Nothofagus* sp.) and rimu (*Dacrydium cupressinum*) seeed fall in relation to mouse population have been well documented. Following heavy seed fall events, rodents are in better physiological condition, and the observed population increase is due to young animals entering the population (Ruscoe et al., 2003), indicating a reproductive response to the increased food supply. The high nitrogen content associated with protein in beech and rimu seeds is shown to be the primary precursor to population increase, promoting higher energy budget, particularly for females to sustain pregnancy and lactation, that are high energy demanding processes. The correlation of New Zealand beech seed fall and mouse breeding cycle finely asserts that mast seeding has no immediate effect on reproductive capacity (litter size or gestation), but sustained breeding activity through winter following the beech seeding that is not normally the routine (Murphy, 1992; Ruscoe et al., 2003). Concomitantly ship rats eruptions have been observed on Stewart Island of New Zealand after heavy rimu seed fall several times over the past 40 years. Shortly after heavy rimu seed fall, rat population shows substantial increase in number, and immediately after the post-peak phase, food shortage causes steep decline in abundance (Harper, 2005). Thus mast seeding produces a large pulse of food resources for seed predators, increasing survival and reproduction.

The influence on reproductive rates, particularly winter breeding, resulting in higher population growth as a consequence of prolific mass-crop productions is also familiar in America and Europe. The mass crop production of American beech and beaked hazel (*Corylus cornuta*) in 1996 definitely was the very example, leading to an extensive growth of deer mice population (Bowman et al., 2001). Similarly the negative influence of decreased after mast seeding is noted in central Europe where after the rodent population shows sharp decline responding to disappearance of available seed. Rodent populations responded to the poor crop of beechnuts and acorns in 2002 by a decline in numbers, predominantly by prolongation of reproductive period, and to the good seed crop in 2003 by an increase in numbers (Cermák and Ježek, 2005).

The extensive annual variations in population size of seed-eating rodents are profoundly influenced by seed-crop production. This phenomenon is documented for a variety of European forest rodents (the wood mice *Apodemus sylvaticus* – Gurnell 1993; yellow-necked mice *A. flavicollis* – Pucek et al. 1993; in addition, the bank vole *Clethrynomis glarealus* – Čermák and Ježek, 2005) as well as for several American deer mice (*P. leucopus* and *P. maniculatus* – Ostfeld et al. 1996, Wolf, 1996). Masting of European beech, *Fagus sylvaticus*, provided a sufficient predator satiation, particularly of the bank vole, such that directly after masting, intensive breeding occurred in contrast to a normal breeding season from April to September (Jensen, 1982; Schnurr et al., 2002). Densities are typically at their peak one year after a heavy seed crop, usually in the next autumn, but they decline rapidly over the winter. Throughout the next year they most often remain much below the long-term average and return to 'normal levels' as late as on the third year after a heavy seed crop (Pucek et al., 1993, Stenseth et al., 2002b).

The mast crops from oaks (*Quercus* sp.) serve as important determinants of community function, and have been understood to influence upsurge of predator mammals in North America (McShea, 2000; Koenig and Knops, 2005) and central Europe (Cermák and Ježek, 2005). Along the West Coast of North America, a variable acorn crops obviously are the primary determinant of increases and decreases in the populations of certain animals, where large acorn crops increase populations of mice and deer, two major acorn predators, along with chipmunk and squirrel. In turn, populations of ticks, major ectoparasites of mice and deer, increase (Koenig and Knops, 2005). And again, since ticks cause Lyme disease, the incidence of the disease rises in response to mouse eruption, which in turn is driven by acorn masting (Ostfeld et al., 2006). As seeds of various tree species (oak and beech) are known to provide excellent food for the rodents, it is likely that the rodents' survival is improved for some time following a mast crop. It was also shown experimentally by the effect of supplementary food (Löfgren et al., 1996). Especially after mass seeding of oaks, winter breeding can induce population fluctuation when other climatic conditions are not operational (Stenseth et al., 2002b). Similar effects of mast crop on vertebrate demography have been demonstrated in various seed-eating bird species, such as tits, jays and woodpeckers in America (Smith, 1986), and large mammals such as wild boar in Europe (Jêdrzejewska et al., 1997).

Similar long-term studies have also ensured that during years of high production of mast, several mice species bred all winter, which results in high densities the following summer (Wolf, 1996). Under normal conditions breeding during winter is not found in rodents. But bountiful mass-crop productions influences winter breeding, and the subsequent year is often marked with rodent irruptions. The mass crop production of American beech and beaked hazel in 1996 definitely was the very example, leading to an extensive growth of deer mice population (Bowman et al., 2001). Nevertheless, survival of adult rodents as well as body weight may not be directly affected by feeding. Nonetheless the annual or supraannual fluctuation in numbers of rodents are a consequence of seasonal reproductive behaviour, which, limited by food availability, constitutes a major factor producing a local increase in population density (Taitt, 1981). Though evidences are that other factors are also directly or indirectly in the play. The intertwining mesh of regulatory structure suggests that rodents are limited by food, space or predators and regulated by intra-specific competition (Murúa et al., 2003) to incite drastic population fluctuations.

Bamboo Flowering – the Real Pied Piper?

If the Pied Piper's secret charm were superbly powerful as to sway all the rats of Hamelin to their destruction, bamboo flowering would be no less forceful charm, of course not to obliterate the rats, but to boost them, as often claimed.

Nearly all species of bamboo seem to have one of two life histories. Depending on the species the range of flowering time ranges from annually to every 120 years. The populations of short cycle bamboos are not recognised as displaying conspicuous seeding synchrony at greater than yearly intervals, and are not implicated relevant incidents of animal population fluctuations. It is the synchronously seeding en masse or the mast, further termed gregarious flowering (specifically for bamboos) of the long lived species at regular and long supra-annual intervals that have profound impacts on animal ecology (Janzen, 1974). Mast seeding marks a massive reproductive output and tragically the death of long-lived plants.

In many cultures the flowering of bamboos is strongly associated with the onset of natural disasters or famines. Whilst evidence for a causal relationship between flowering and floods or earthquakes does not exist, bamboo flowering is known to cause increases in rodent populations, which multiply rapidly due to the sudden increase in seed availability. Spurious explosions in the populations of rodent species such as *Nesokia*, *Mus*, *Rattus*, *Golunda* and *Rhizomys*, concurring with bamboo flowering have been reported from various parts of India (Mahadevan et al., 1961; Santapau, 1962; Mohan Ram and Hari Gopal, 1981; Chauhan and Saxena, 1985; Kumar and Pathak, 2002; Chauhan, 2003; John and Nadgauda, 2003). The occurrence of similar phenomena has been reported from many other parts of the world, such as Madagascar, Burma, Japan, Laos, Brazil, Chile and Argentina (Janzen, 1974; Gallardo and Mercado, 1999; Jaksic and Lima, 2002; Douangboupha et al., 2003). Due to seed surplus and ideal nesting sites, mast seeding of bamboo has been associated historically with mouse outbreaks constantly followed by invasion of homes and subsequent calamities of different sort. Many rodents but not all appear to have insatiable appetite for these bamboo seeds and fruits. When the seed supply is depleted after consuming the bamboo seeds and germination, the rodents turn to other sources of grain, such as stored cereals or crop still standing in fields, and thereby cause famines. Besides the non-linear climatic signature in population dynamics, the periodic event of bamboo flowering and mast seeding therefore strongly influence rodent population growth rates. Because of this, bamboo flowering may be used as a signal for forecasting outbreaks and for implementing information and health policies to avoid human-rodent contacts in specific areas.

As early as 1552, chroniclers noted massive rodent irruptions or outbreaks in several parts of South America and called them 'ratadas' (rata=rat) in both Portuguese and Spanish. At least 70 ratadas have been observed from historical archives, and 67 of them are well-documented. Although no attempt has been made to investigate the natural causes of these outbreaks, naturalists detected that massive flowering and subsequent mast seeding of bamboos in Brazil and Chile preceded several rodent irruptions. It come to light from the exhaustive analyses of the records that ratadas are not figments of the imagination of early chroniclers, but are sound records made by professional naturalists (Jaksic and Lima, 2003). They may not be cyclic as presumed by early observers, but rather triggered by exogenous factors such as bamboo blooms and rainfall peaks. There are two types of ratadas: bamboo associated and rainfall-associated, which have occurred with approximately equal frequency. The overall picture further seems to present a distinct ENSO driven high rainfall, that in turn increase primary production, and then outburst of rodent population.

Several bamboo species of the genus *Chusquea* occurring in the temperate rainforests of Southern Chile undergo fruiting episodes that extend from 15 to 40 years (Seifriz, 1950). The most recent mast seeding of *C. valdiviensis* lasted from 1990 to 1993. The seed surplus triggered an explosive population growth of rodents. The outbreak consisted mainly of the rice rat, *Olygoryzomys longicaudatus*, although increased population of *Abrothrix olivaceus* was also recorded (Gallardo and Mercado, 1999). It was reported that the suddenly irrupted rice rats invaded homes and granaries, even forcing people to leave certain areas. Intriguingly the ratadas appeared to indicate close association with rainfall in this case also.

The occurrence of explosive rodent outbreaks in the uplands of Laos was originally reported by Schiller et al. (1999). Based on information obtained during interviews with farmers and agricultural officers, and on the returns from rat bounty systems, bamboo flowering is mentioned in connection with 16 of the 23 rodent outbreaks. All but two of the 23 rodent outbreaks in Luang Prabang province are said to have occurred during the wet season; the exceptions are outbreaks that extended across the wet and dry seasons in 1991 and in 1995. Thus the effects are primarily brought about by climatic conditions, while bamboo flowering plays a rather insignificant role. The widespread and prolonged nature of rodent outbreak in Laos suggests the possibility of some underlying climatic control, specifically rainfall and ENSO events (Douangboupha et al., 2003).

Extra food has an immediate effect on population densities of native rodents (Murphy 1992; Wolf, 1996), and poses a causal relationship between the cycles of bamboo blooming and mouse outbreaks. After the population peak, exposure, hunger, and intraspecific competition produce a precipitous drop in the rodent populations. Since population fluctuations are related to seed availability (Murúa et al., 1986), the pleiotropic response affects population density parameters, reproduction rate and length, body weight and sizes, migration patterns, and behaviour. Thus, the addition of extra food may result in a two- to threefold increase in the population density of rodents.

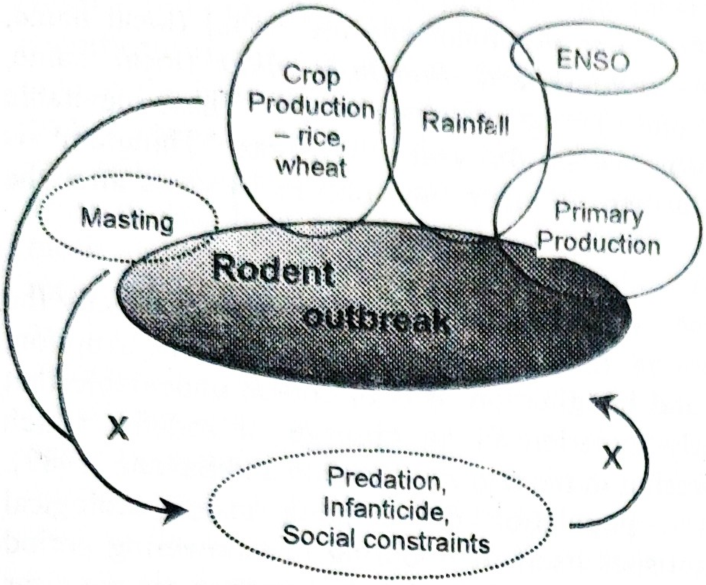
Crop Production – rice, wheat
Rainfall
ENSO
Masting
Primary Production
Rodent outbreak
X
X
Predation, Infanticide, Social constraints

Fig. 4. Factors responsible for causing rodent irruption through a network of interaction.

A cumulative observation in India was reported by John and Nadgauda (2002). Gregarious flowering of bamboo (*B. tulda*) started in September, immediately after monsoon rain. By the following winter and summer, the seeds were profusely shed, that appeared to attract the predator rodents, species of *Mus* and *Rattus*. At the end of summer the number of rats was noticeably increased, even the usual nocturnal feeders were seen eating during mid-days. But with the onset of rainy season, the leftover seeds germinated, causing abrupt food depletion for the erstwhile gluttons. Following depletion of the bamboo seed-fall, mass emigration of rodents into adjacent agricultural habitats is claimed, leading in some cases to heavy crop losses and even famine (Singleton and Petch, 1994; Schiller et al., 1999). The sudden transition impelled a mass exodus of rats out of the bamboo forests in to nearby farmlands, where they started to play havoc with the standing crops and granaries, thus the harbinger of famine.

The dynamic interaction between bamboo flowering, bamboo-seed predators (mainly rats), climatic change (the sudden transition from summer to the rainy season) and the rapid transformation of seeds into seedlings (not a gradual depletion), is therefore overwhelming. This also indicated that the outbreak of rats occurs at the end and not during seeding. The apparent causal relationship between mast seeding and diseases is the logical derivation of the fact that whenever densities of native rodents increase abnormally, increased risks of human infection are expected due to a larger natural reservoir (Davies et al. 2005). Thus the chains of interaction always impose epidemics. Janzen (1974) has remarked: "Rats are so fond of bamboo seeds that the widespread seeding of [Burmese] bamboos may induce a regular plague of them in the neighborhood. This sometimes results in famine and is followed by epidemics and disease since the number of rats increases to such enormous proportions that the sowing of field crops becomes impossible".

The Mizo Connection

Bamboo forest covers 12,54,400.00 ha out of the total area of 21,090 sq Km of the Mizoram State, approximately 31%. The bamboo forest contributes to 14% of all India bamboo area of 8.96 million ha, which further constitutes 11.71% of the 74.96 million ha of forest area of the country. The total bamboo yield of Mizoram is 32,37,689 MT/Year (Bhatt *et al.*, 2003). In Mizoram, the famines associated with the long interval but periodic masting of *Melocanna baccifera* which is by far the major dominant species (95%) (local name, 'Mautak' and previously named *M. bambusoides*) and *Bambusa tulda* (local name, 'Raw\hing') are locally known as 'Mautam' and 'Ṭhingtam', respectively.. These inevitable catastrophes befell at an interval of approximately 48 years. Whereas 'Ṭhingtam' is associated with a famine of lesser magnitude than 'Mautam' and occurs 18 years after the occurrence of 'Mautam'.

The most heralded events during these 'Mautam' and 'Ṭhingtam' are not exactly the flowering and subsequent death of the bamboos, rather the accompanying rodent irruption, particularly fabricated with myths, fictions and imagination. It is of course undeniable that Mizoram and the nearby regions frequently experienced an upsurge of rodents which interestingly coincided with the bamboo flowering in the region (Chauhan and Saxena, 1985). After flowering for 2-3 years the bamboo population die creating major ecological disturbances unless the new population establishes itself. It is during this flowering period that the rodent population shown rapid growth. Reasons behind the phenomenon are not clear as yet but a probable one according to Chauhan and Saxena (1985) may be that continuous availability of bamboo seeds serve as food for the rodents. Laboratory tests conducted by Saxena, Department of Zoology, Delhi University, showed that bamboo seeds had a definite impact on the reproductive rate of rats. The population multiplied at a faster pace when fed on bamboo seeds and the possible reason cited was presence of steroids in the seeds (Prakash, 1998, through personal communication). These have as yet not been extracted however and so it still remains a hypothesis, and we are still shrouded with anything but the experimental evidences to alleviate ourselves with such a bold and bald claim.

Unfortunately, despite such a scientifically attractive issue proper research investigation is yet hanging by the hands of the future. The only analytical document is that of the last Ṭhingtam (1976-1979) by Chauhan (2003). An observational study was conducted in the north-eastern region of India with Mizoram as the epicenter during 1976-79, the period of flowering of the bamboo, *B. tulda*. According to historical records, the flowering of *Bambusa* in 1881 was accompanied by extensive rat irruption, which caused damage to such an extent that it resulted in almost famine-like conditions. However the next Ṭhingtam of 1977 had no considerable effect. According to Kumar and Pathak (2002) no extensive crop damage was experienced following 1977 bamboo masting. This can be easily understood as *B. tulda* covers a very small portion of the land, its flowering therefore could not have attracted large population explosion.

During the Ṭhingtam investigation, *Rattus rattus brunneusculus* constituted the major part of the collection (92.5%) in Mizoram. In Manipur and Nagaland, the Himalayan rat, *Rattus nitidus*, was the predominant species. Other species collected in low numbers were *Rattus bowersi mackenziei*, *Bandicota* sp., *Cannomys badius*, *Rattus rattus*, and *Mus musculus*. The first three species occurred in the cultivated areas whereas the latter species occurred mainly in tribal settlements and granaries. They caused extensive damage to the paddy crop. Due to deforestation in preparation for cultivation or after harvesting of crops, perhaps these rats disperse to bamboo forests and later recolonised freshly cultivated land. The presence of live burrows, paddy husks, damaged panicles, cut leaves and faecal matter on their runways were signs of their increasing population and activities.

The population indices showed marked monthly changes, both in abandoned and freshly cultivated fields during 1978-79. In the abandoned crop fields, the maximum population was observed in January (post-harvest period) following high breeding activity from July to October during the crop of the preceding year. In freshly cultivated areas, the significant rise in populations of rats in July, before the onset of breeding, was likely to be due to the immigration of large numbers of rats from surrounding areas in search of sown paddy grains. Later, with the exhaustion of paddy grains, either due to consumption by the rats or their germination into seedlings, the population temporarily dispersed to surrounding areas in search of alternative food. The factors governing these fluctuations may be both biotic and abiotic. Monthly fluctuations in the relative density of the rats have been discussed mainly in relation to biotic factors such as seasonal periodicity in breeding activity and food availability. These biotic factors have been found to be of considerable importance in the regulation of population density of many rodent species the population shows an increasing trend coinciding with the growth of the paddy crop, especially the development of rice panicles, which are their favourite food, and many vegetables. The onset of rainfall could possibly be an indirect factor regulating the population by causing vegetation growth, and thus an increase in food supply. Growth and maturation of paddy panicles also probably attract rats from surrounding areas, which – along with intense breeding – results in further population increases. Predictably the population was highest during November December, the period when paddy was harvested.

The most surprising outcome this investigation is that the common bamboo rat, *C. badius*, that is believed to be the only species that causes sufficiently extensive damage to paddy crops to result in famine, was not found to be of much significance. Despite a constant vigil, no sign of rat migration from jhum to bamboo forest or vice versa was observed during the unremitting Ṭhingtam. The rats mainly inhabited paddy fields, and showed variation in their numbers in relation to the crop cycle during the flowering of *B. tulda*. Only a few rats were noticed in the forests during this period. This suggests that the extent of bamboo flowering and seed production during these years may not be sufficient enough to attract the rat population. The flowering of the bamboo had no measurable effect on rodent population dynamics.

The ultimate question from such episodic rat population coinciding with bamboo flower is what intervening factor(s) can be inferred from the events? Here we need to remind ourselves that concrete empirical evidence is still out of reach. However we can do a little rationalization from the available historical documents (most elaborately by Rokhuma, 1988) in comparison with other scientific reports from other parts of the world. Looking at the first clear record of the 1911 Mautam, it is amazingly obvious that the immediate preceding year 1910 saw a rarely bounty harvest of rice, estimated to be an excess of surplus for every family in the land. In 1911 *M. baccifera* was then in full bloom, concertedly famine shadowed the whole country. The 1929 flowering of *B. tulda* was tragically marked with enormous landslide due to an unusually high precipitation. Though the land including paddies was much mutilated, copious supply of water offered excellent vegetation, so famine was hardly heard of.

Another surprise can be noticed for the last Mautam of 1959. Towards the middle of '50s exceptionally high productions of paddy were again recorded. As Rokhuma (1988) avowed, "Perhaps, this might be the highest record of production in Mizoram even for years to come." Though the immediately following years experienced frequent upsurge of rats, high yield of grain resumed till 1958. It was heralded that the total production would support the whole population for 13 months – a true hey day, full of hay. Then the most historic famine of all in Mizoram befell in 1958-1959, with the bamboo flowering in full swing.

Despite deficiency in detailed statistics it can be conceived rather unexpectedly that in all of the cited incidents, bamboo flowering though apparently associated may not be the driving factor for rat population dynamics. In fact closer assessment of the records indicates much to the contradiction of the usually alleged connection of rat irruption and bamboo flowering, high production of rice may be after all the causal if not the principal factor. Rat population outbreaks driven by rice production have been heavily documented in rice growing regions (Schiller et al., 1999; Tristiani and Murakami, 1999, 2003; Lathya et al., 2003; Rao, 2003). Besides there have never been any consistently credible explanation for the masting of bamboo as the direct cause of rodent outbreaks even though there appears to be a high correlation (Gallardo and Mercado, 1999; Douangboupha et al., 2003; Jaksic and Lima, 2003). Study of the reproductive behaviour of the dominant species (*R. rattus brunneusculus*) in Mizoram has not provided the type of breeding normally expected for the initiation of population eruption (Chauhan, 1981). The participation of other factors must be taken into consideration. The role of rainfall as a density dependent factor is also highly conjecturable particularly in connection with the 1929 Ṭhingtam in spite of the lack of records in other episodes, as high rainfall occasionally bestow increased primary production leading to increased rodent populations through complex temporal changes (Hughes et al., 1993; Madsen and Shine, 1999; Jaksic and Lima, 2003; Krebs et al., 2004; Lima, 2005, 2006b; Madsen et al., 2006).

Mautam, Manna, Misconceptions – the Nuts and Nots

If bamboo flowering were, as often asserted, a blessing in disguise it would be but a terrible one. The Mizoram Mautam of 1958 was the root of all "weeping and gnashing of teeth" that lasted for two decades after 1966. The resultant famine provoked a never retreating guerrilla war between the disgruntled Mizo people and the Indian federal government.

Our scientific standpoint on the possible effects of enhanced population increase of rats with respect to bamboo flowering is invariably feeble. We are practically devoid of any in depth field records, experimental demonstrations, and validation of the chemical constituents of bamboo seed as a potential source of population dynamics. In spite of such an enticing scientific investigation concrete understanding is still far off. To worsen the situation with, the interpretations from preliminary tests available so far are highly contradictory to the known facts of scientific data.

But we do have some chemical analyses (Table 2), the most recent one from the Animal Husbandry & Veterinary Department of Mizoram. They observed an unusually high amount of manganese (580 ppm), that high concentration of Mn in bamboo may be attributed to rapid reproduction in rats (Sangnghina, 2006). They are right about one thing, in that the basal or normal levels of Mn in diet is merely 50 ppm, but the rest is no better than fiction. The truth is, scientific evidences are absolutely on the contrary. Mn is an essential mineral required for normal amino acid, lipid, protein, and carbohydrate metabolism, thus for normal growth and reproduction, but in trace amount. If considerably above the basal level it has been recently demonstrated to be highly detrimental to adult reproductive functions, and play a regulatory role in the onset of puberty in male and female rats (Pine et al., 2005).

Table 2: Comparison of analyses on nutritive chemicals from *Melocanna baccifera*

Chemical	Shoot[1]	Shoot[2]	Fruit	
			Analysis 1[3]	Analysis 2[4]
Protein	4.6 %	3.6 %	11.5 %	15.0 %
Fat	0.2 %	0.5 %	0.2 %	1.5 %
Water	89.1 %	75.5 %	NA	80.0 %
Fibre	1.5 %	1.5 %	NA	13.5 %
Carbohydrate	5.0 %	6.1 %	50.3 %	NA
Copper	NA	NA	NA	11.54 ppm
Iron	NA	NA	NA	894.4 ppm
Manganese	620 ppm	NA	NA	580 ppm

[1] RIRDC, Australia (Midmore et al., 1998).
[2] ICAR, Meghalaya (Bhatt et al., 2003)
[2] Forest Research Institute, Dehradun (Rokhuma, 1988, 2002).
[4] Department of Animal Husbandry and Veterinary, Government of Mizoram (Anon, 2006).
NA – not analysed; ppm = part per million.

I may seem a bit like attempting to make a mountain out of a molehole, but in actuality, the underlying principles have enormous scientific impacts. I can't help it but end the derogatory audacity of the late Noble laureate Francis Crick that the kind of credulity we are generally prompted with our scientific know-how "is a beautiful example of confusion that can be brought about by ignorance (*Of Molecules and Men*, 1966, p. 19)." Ironically most of us are too much in the dark even to get confused in the first place. And before digressing too much, our point demands further clarification.

Mn is present in virtually all diets at low concentrations. The US National Research Council (NRC) has established an estimated safe and adequate dietary intake of 2-5 mg/day for adults. While naturally occurring deficiency states have not been recognized, Mn-induced neurotoxicity from excess respiratory or dietary exposures has been well described (Aschner and Aschner, 2005). Systematic studies have been performed on rats using 50, 500, and 1000 ppm of Mn. The convincing observation was failure in reproductive activity, along with retarded growth in the young ones. Histology of testes and ovaries also showed reduction in spermatogenesis (formation and development of sperms), atresic follicles (destruction of vital tissues in the ovary), and persistence of corpus luteum, indicative of dysfunction of gonads (Vargas, 1984), and abrupt regression of pregnancy in newly impregnated rats (Bataineh et al., 1998). Similar effects along with severe decreased hormonal levels were also observed (Laskey et al., 1982; Cheng et al., 2003). Inhibitory effects on steroidogenesis (the process of formation of sex steroid hormones) in Leydig cells of testis accompanied by apoptosis (cell death) and reduced enzymatic activities have been unequivocally demonstrated (Cheng et al., 2005). Assessment of rats treated with 550 mg/kg/day of Mn for 19 days showed significant reduction in body weight and food consumption, and associated with loss of cognitive behaviour (Torrente et al., 2005). Excessive Mn accumulation in the central nervous system (CNS) is an established clinical entity, referred to as manganism. It resembles idiopathic Parkinson's disease (IPD) in its clinical features, resulting in adverse neurological effects both in laboratory animals and humans (Aschner and Aschner, 2005).

Consumption of edible parts of bamboo poses serious physiological hazzards. Experimental evidences point that Bamboo shoots also have adverse effects on male reproductive traits in rats. Rats treated with extract of the tender shoots of *Bambusa arundinaceae* indicated significantly decreased sperm motility and sperm count in the epididymis, with reduction of epithelial cells (Manonayagi et al., 1989). The behavioural effects include considerable loss of libido. Vanithakumari et al. (1989) found that the number of cohabited female rats successfully inseminated was significantly reduced upon administration of 300 mg/kg per day of the extract for 7 days. Bamboo shoots are also shown to possess anti-thyroid peroxidase (TPO) activity, a prime factor of endemic goitre. Prolonged bamboo shoot consumption affecting inhibition in TPO activity in rats was found with raw, raw boiled and cooked extracts leading to a state of hypothyroidism. In addition, extra iodide could not fully neutralise the anti-thyroidal effect (Chandra et al., 2004a,b). Thyroid activity is crucial for normal body development and metabolism. It is thus highly advisable not to take bamboo of any part, or if taken, in moderate quantity.

So much for the toxicity of bamboo, let us delve a little into the protein aspects. It is well established that protein diet is the most crucial factor for physical quality in animals. Rokhuma (1988) evaluating the FRI data surmised with versatile scepticism: "Considering the chemical contents and their respective quantities in bamboo fruits, it does not perhaps appear to be so high in nutritious value" (cf. Rokhuma, 2002; Lalnunmawia et al., 2004). A similar preposterous conclusion is drawn while comparing the chemical constituents of the fruit of *M. baccifera* to that of rice (Lalnumawia et al., 2005). It is ironically clear from the table that a bamboo fruit must be amazingly nutritious, particularly in taking in to account that our staple diet, rice (with protein = 7%) is only half as nutritious. To make such a logistic gullibility worse the high nutrient quality was already acknowledged far back before any Mizo had become literate (see Janzen, 1974). Moreover if what is often claimed is taken to be true, that the bamboo fruits being 'much relished by rats', it can be presumed with impunity that it would be no miracle at all if not all or most, but significant amount of the bamboo fruits were completely devoured by rats not to say other animals in the previous Mautam incidents, and the land is bereft of any standing bamboo. This should be scientifically feasible considering a vivid account of an almost total destruction of bamboo seedlings (*Cehalostaschyum*) in Burmese mast crop as a consequent of predatory plague of rats, resulting in a local extinction of a small bamboo cohort (Janzen, 1974). This contemplation should be strengthened by the fact that several animals ranging from crabs, fishes, cows (Rokhuma, 1988), birds, pigs to elephants, including Chilean and Japanese (Janzen, 1974;) find the same enticement to bamboo fruits. And if the massive attack of rats on the standing crops after exhaustion of bamboo fruits is the harbinger of famine as generally speculated, I see no reason to believe our heralded *M. Baccifera* to have been completely annihilated or on the brink of extinction. Logically there would have been no more of Mautam, and its accompanying rodent outbreak, and our discomfort for that matter. Yet bamboo still covers a major portion of the Mizoram forest, and we still manage to consume as many 4326.34 q of bamboo shoots per year, so much so that the "leftovers" alone grow to a span of 30.8% of the forest (Bhatt et al., 2003).

Laboratory test conducted by RN Saxena, of the Department of Zoology, Delhi University was acclaimed to show faster multiplication of rat population when fed on bamboo seeds, as they are rich with steroids (unpublished information from CSE, 2006). But this presumption is strongly negated by the experimental verification following the 1959 Mautam rat irruption in northeast India (Mahadevan et al., 1961). Firstly, laboratory acclimatized rats did not relish bamboo fruits and flower *per se*, in stead preferred the standard feed (Table 4 & 5). The bamboo ingredients have to be supplemented with normal diet. Secondly, in groups of control (regular feed without bamboo) and bamboo supplemented diet, reproductive efficiency were recorded with astounding statistical observations. The rate of reproduction among bamboo fed groups was not any faster to those of the control group. In fact, among higher bamboo diet, gestation was significantly longer, accompanied by reduction in litter size. This can be considered strongly corroborated with the known facts of Mn toxicity in mammalian reproduction, as bamboo parts are highly concentrated with the trace element.

Lastly, there is no indication from a source of any kind that bamboo seeds are rich in steroids. The analyses clearly show very low level of fats making the claim an unfeasible case of speculation. Rats on bamboo diet did not show any significant estrogenic property to enhance reproduction, practically nil at the tested levels, while the drug (here stilboestrol) resolutely showed estrogenic influence.

Table 4. Comparison of the effects of an estrogen and bamboo flower extracts on reproductive biology of female mice.

Group Number	Addition to 100 g normal diet	Live wight in g	Uterine weight in mg	Difference compared to control
I	0	5.33±0.61	3.01±0.42	-
II	Stilboestrol 0.75 :gm	5.5±0.62	5.58±.63	Highly significant
III	Bamboo extract 8 gm	5.33±0.61	3.20±0.55	-
IV	Bamboo extract 1.6 gm	5.67±0.76	3.30±0.42	-

Table 5. Effects of bamboo flower diet on reproductive performance in female mice (adapted from Mahadevan et al., 1961).

Group Number	Level of bamboo flowers in diet %	Gestation period in days	Litter size	Wieght per new-norn gm
I	0	30.00±2.61	8.25±1.44	4.88±0.05
II	2	25.7±1.25	8.0±0.0	5.10±0.11
III	15	36.75±10.2	7.25±0.85	4.80±0.13

Concluding Remarks

Rodent outbreaks have dramatic repercussions on human health and on agriculture. Gaining a better understanding of what causes these population dynamics is a priority for research. Despite occurring in such large numbers, rodents have not been studied in great detail in the wild, particularly in connection with the bamboo flowering incidents. Though there have been a number of studies on the population dynamics and community ecology of rodents in Europe, North and South America, and Australia it has not been possible to fully comprehend their behaviour and habits since they are largely nocturnal and may live in inaccessible burrows.

As in the case of "ratadas", bamboo flowering may not necessarily be the prime and sole factor for rodent outbreak. But there is more to rodent outbreaks than bamboo blooming. Even though coincidental phenomena apparently exists, relatedness between rodent irruptions and bamboo flowering may be due to more prevalent factors. Gilmore (1947) was puzzled that he could not detect mast seeding of bamboo prior to or concurrent with a massive and widespread rodent outbreak in early 1944 in southern Peru. In fact no bamboo-associated rodent irruptions have ever been documented in Peru though ratadas were familiar occurrence, but they are typical of southern Chile and southern Argentina. On the other hand no rainfall-associated outbreaks have ever been recorded in Brazil. In Argentina, rainfall-associated ratadas appear to be more prevalent than bamboo-associated ones. Climatic observations have supported rainfall-associated ratadas to be ultimately caused by intrusions of ENSO (Jaksic, 2001). The last six rodent outbreaks in Peru and Chile have occurred 1–2 years after the El Niño events of 1940–1941, 1972–1973, 1987–1988, 1991–1992 and 1997–1998, which are all coincidental with high rainfall, and some rodent species increase after high-rainfall winters (Jaksic et al., 1997; Lima et al., 1999a). Although ratada connections to El Niño are less than perfect, they survive statistical testing and thus are predictable (Lima et al., 1999b, 2001). With every El Niño there has been a corresponding ratada, but the extent or intensity of the irruptions has been different (Jaksic, 200; Jaksic and Lima, 2003).

Rainfall caused rodent outbreak is largely typified by the so-called Navajo incident of USA in a rather horrible history of epidemics. Notably, unusually heavy rains and snows followed six years of drought in the epidemic area in the spring of 1993. The following year observed a 10-fold increase in the usual density of the deer-mouse population in Arizona, Colorado, and New Mexico (Hughes et al., 1993). Because rodents in general have high reproductive rates, small rainfall-induced differences in the duration of their breeding periods can result is extensive temporal oscillation in abundance. That is when the mice-laden hantavirus started to take away human lives, not by the mice but the hantaviruses.

In addition, rat outbreaks may be viewed more broadly as pulsed resources (Ostfeld & Keesing, 2000). That is, as intermittent resources of dramatically higher than normal levels, which then become depleted with time. Such pulsed resources have been described in association with mast seeding (of bamboos in our case) and with increases of primary production following some environmental cue. The effects of pulsed resources have been tracked for up to three trophic levels in several parts of the world (Ostfeld & Keesing, 2000; Jaksic and Lima, 2003), and rainfall associated to rat irruption in Mizoram conform closely this pattern, from vegetation through herbivores to carnivores (Jaksic, 2001; Jaksic and Lima, 2003). Nevertheless, no follow up of bamboo-associated rat population fluctuations is yet within the grasps of scientific inquiry, much to our dismay. But as soon as rat irruptions become predictable from bamboo blooming, it should be interesting to study how, or if, they propagate to the top predator level, thus enabling us to learn more of the ways communities respond to these pulsed resources.

We have come to a logical conviction that a bamboo flower, fruit or seed has no direct influence on the rat demography, but may be an indirect one, if at all, by providing an alternative of a nutrient rich diet to their usual food restriction. As already accounted, extra food has an immediate effect on population densities of native rodents (Wolf, 1996: Stenseth et al., 2002b), reducing their physiological and social constraints including infanticide, and poses a causal relationship between the cycles of bamboo blooming and rodent outbreaks (Bomford and Redhead, 1987; Innes et al., 2001). Survival of the litters thereby results in increase in the number of juveniles, which are known to comprise the majority of the prevailing population. The evidence can be clearly pictured from the South American rat outbreak of the early 1990s. When outbreak samples were trapped successfully, no evidence of pregnancy and no reproductively active males were collected in any sample. Since no fully adult animals were present according to their reproductive condition, no over-winter survivors but only medium- and large-sized juveniles apparently formed the outbreak samples (Gallardo and Mercado, 1999). This line of reckoning also provides credence to the observation of the outbreak epitomized by juveniles only.

In simple sense bamboo does not appear to boost any reproductive behaviour, rather it facilitates higher survival of the litters as they are averted from being gulped down by the adults. Increased survival of the juveniles would therefore lead to a massive production of individual in the successive generation. This is indeed strongly supported by a recent experiment in which individually housed rats subjected to short-term food restriction displayed more territorial aggression toward conspecific intruders than controls maintained on a free-feeding diet. Under abundance of food individual competition is greatly abhorred, but when food supply declines, social intolerance increases and serves to limit the development of large feeding groups (Lore et al., 2006).

Moreover the potential threats to reproductive physiology after long-term ingestion of high levels of manganese have been unambiguously demonstrated (Bataineh et al., 1998; Cheng et al., 2005). Therefore the general assumption of the direct liaison of dramatic rat population oscillation with bamboo flowering has a feeble standpoint. It may be too impulsive to rule out the possibility of bamboo masting as the basic factor for rat irruption, there is a firmer ground to encompass other factors, rice yield and rainfall being the foremost. Natural irruptions of rodents are factually triggered by rainfall and possibly rain-induced food availability. The bamboo fruit, shoot or flower as we know it may be nutritious in protein, but equally detrimental to reproductive physiology. The foundation of our belief is thus laid on sandy ground. Of all the impending calamities we are still much restrained from the underlying natural phenomena, the myths and the facts are far from being sequestered, perplexing us which to render unto Caeser or to God. As naive as they sound the native claims are often exaggerating, lending a more necessity for proper methodological examinations to affirm the validity of any of these mutual claims.

Let us meet our end, not of life, but of this treatise, paraphrasing the concluding statement of A. R. E. Sinclair (1991) – rodent management requires a scientific approach, and the science of rodent management requires managers to conduct experiments. Knowing fully well our helplessness, lack of research initiatives and scientific investigation, let us lament ourselves with the refrain of *The Pied Piper of Hamelin* to conclude our humble exposé:

So, Willy, let me and you be wipers
Of scores out with all men - especially pipers!
And, whether they pipe us free from rats or from mice,
If we've promised them aught, let us keep our promise!

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The Anti-Famine Campaign Organisation Mizoram (Tando Kawl)
July 21, 1951

MAUTAM CHUNGCHANG

C.Rokhuma

Vawiin hun leh hmun ropui takah, mi pawimawh ber berte hmaa thu sawina hun ka nei thei hi, kan hotute chungah leh heta lokal zawng zawngte chungah hian ka lawm em em a ni.

Hei tunah ka kum 90-na ka hmang ṭan ve ta a; Ṭhingtam vawi hnih leh Mautam vawikhat ka lo paltlang tawh a; Mautam vawihnihna kan lut tan leh ta bawk a, vannei ka inti hle a ni.

Mizoramah hian mau chi hrang hrang, hunbi neia tâm ṭhin 10 aia tam a awm a; chung zingah chuan a mau chi khat tam dan ang zelin a rah tlantu an tamin, an pawi khawih dan pawh a nasa hlei a ni. Mau hrang hrang rah tlantu zinga tam ber leh pawi khawih ber chu sazu a ni. Hmasang aṭangin Mizoram hi sazu tamna ram a ni ve hrim hrim a; Mautam lai leh Ṭhingtam lai kher lo pawhin sehfa zual kum hi Zoram khawi khawiah emaw chuan a awm ve fo reng ṭhin a, tun thlenga ka la hriat reng chu, Tanhril khuain Mualkhang tlangdung tawp leh Zawngbete tlangdung tawp, mual dung inep chiah 1937-a neih kum, buh ṭha tak mai, melthum pawn, lo hla ber neih kuma kan hlim tehlul nen, lo neitu tam tak hlawhchhama min siam kum kha ka la theihnghilh thei lo. Mautam kum a ni lo va, Ṭhingtam kum pawh a ni lo; ram a la dur ṭha a, sazu hi ram tinah a tam ve reng reng a, inau ei pha tawkin Zoram hi an dap chhuak ve hrim hrim a ni awm hle mai. Chuti ang kum sawi tur chu Zoram khaw hrang hrangah hian a lo awm reng reng ṭhin a ni tih hi kan hriat hmasak a ṭulin ka hria. Kum 1997 aṭang tawh khan hmun hrang hrangah mau rah bing hmuh tur a awm tawh a, kum thum chhung lekin sazu mei pawh nuai hnih chu kan lei hman pang a nih kha.

Mau rah leh sazu:

Sazuin mau rah a ei em? Sazuin mau rah ei ni se a pun phah reng em? tih hi Zoram mipui ti ti a lo ni ta hial a, mi thiam rau raute ngaihdan pawh a phir hle mai. Ka Research Centre-ah chuan, khaihlak awm lovin March, 2006 aṭang khan, ram aṭanga sazu lokal tlan turin mau rah buara hnih zet ka chhung a, a kiang artificial hole (burrow)-ah mau rah leh buhfai hmanga chawmna hmun hran ka nei bawk a; May ni 5-a buhfai, belthlenga ka dah thar chul mamah chuan a tukah sazu no mit keu tawh, mahnia chaw ei thei ek a lo awm ṭeuh mai a, ka chhiar ta a, ek tlang 80 chiah a lo ni a, a hnu deuhvah 82 a lo awm leh a. Kum 8 lai ka khawi chhung hian, a pui tling ek pahnih/pathum a awm ṭhin tih mai lo chu a awm ngai si lo va; mau rah an tlan tak tak hnua hetiang a lo awm ta mai hi; MAU RAH HI SAZUIN AN NGEIH A, AN PUN PHAH A NI tih hi a chiangin ka hria. Tunah hian buara hnih zet an ei zawh tak avangin ei tur an nei lo va, an thinur a, ka herhsawp thutthleng pahnih savun chu an ei zo vek tawh, vaithang hrui an seh chat zel bawk.

Mautam hunbi:

Pathianin Zoram leh a chhunga michengte a hmangaih tih, tichiangtu ber pakhat chu, Ṭampui Mitthi tling khawpa Ṭhingtam leh Mautam, hunbi fel thlapa a thlentir hi a ni. Hmanlai chuan tun angin phai buh ei phakah a awm lo va, hriat lawk loh, inbuatsaihna ṭha awm lo, lo ni sela chuan, mikawlh sakawlh nena inpawmchilh chung chuan, he an siamtu chung Pathian tana missionary tir chhuak tur ram hi Zofaten kan luah lum pha hauh lo vang.

Mahse kan tana ṭha turin Pathianin hunbi fel tak, mi mawl berte pawhin an hriat thiam theih turin rem min ruatsak a. Ṭhingtam aṭanga kum 30-na chiahah Mau a tâm a. Inbuatsaihna rei tawk deuh ngai, ṭam nep zawk deuh a kum 18-naah thing a tam ve leh a, chuti ang hlir chuan a inbanlek chho zel a ni.

Thing leh Mautam sehsam:

Sehsam awmzia chu a dawn hnaia thil thleng tihna a ni. Heng thil thleng ṭhinte hi a mak tih mai lo chu sawi theih kan nei lo. A intawng fuh kan ti zawk dawn em ni ang? Chungte chu han sawi ila:-

a. Simeikhu (Comets): Hmasang khawvel mihringte pawhin, simeikhu hi thil a chhe zawngin emaw, a ṭha zawngin emaw lo thleng tur hrilhlawkna angin an lo ngai ṭhin reng a, Halley's Comet ngat phei hi chu, simeikhu huaisar taka an neih a ni. British-in Mizoram a awp china Ṭampui thlen dawna simeikhu lo lang ṭhenkhat i han sawi dawn teh ang.

Ṭam kum	Ṭam tur hming	Simeikhu hming	A lan kum
1911	Mautam	Halley's Comet	1910
1929	Ṭhingtam	II Schwassmann/Wachmann	1925
1959	Mautam	Marco's Comet	1957
1977	Ṭhingtam	Comet West	1976
2007	Mautam	III Schwassmann/ Wachmann	2006 May thlaah

b. Thangnang (Cinamon beetle): Kum 1976-ah khan a kum lehah Rawṭhing a tam dawn tih a chiang a, thangnang pawh a kai nual tawh a; chutih lai chuan, Central sawrkarin sazu chanchin zir chiang turin Delhi University-a Zoological Deptt. Head, Dr. Prasad Aizawlah an rawn tir a, sazu kaw lai turin Pu Vanṭhuama, Agri Officer lian nen Siatualah kan han hruai a. Chutah chuan thangnang chanchin ka zawt a, Delhi tlangah thangnang chanchin an lo hre miah lo mai a; chuvangin kan hnaivai thil a niin ka ring ta zawk a ni. India rama rannung chanchin zirna khurpui -Research Centre meuh pawhin, Mizorama a chaw rawn tian an sawi dan hmang hian an hre miah lo tih a chiangin ka hria.

Kan Mizo pi leh pu te khan, an sawi dan chuan, "Mizoram piah hmar lam, Khawbawn tlang lam aṭanga, zana an kaina tur hmun thleng tâwk turin, tun hma kum 48 vela an thlahtute kaina hmuna kai turin an lo chhuak ṭhin a ni," an ti a. An hre dik emaw dik lo emaw, kan pute khan thil chu an lo chhui thui ve hle mai. Kan hriat chinah chuan hmar lam aṭanga lo kai chu an ni ngei mai a; an tam em em dan lah hi a makin a mak a; hmania Saichal VCP-in min rawn hrilh dan phei chuan an khawtlanga thangnang kai tamzia chu thingzar malpui rual rual hi a tliak hmawk hmawk a, thing kung lian fe fe a kur dulh dulh a; cement bag khat khatin an rut a, an pu zut zut mai a, a tam reng a rawn ti a ni.

Thangnangin an kaina hmuna an lo kai hian an insawn tawh chuang lo va, rannung dang angin an ṭi ve chuang lo va, engmah an eiin an in bawk lo va, an thau em em a, a ngeih mi tur chuan tui an ti em em a, an thau phah hial ṭhin; a hriak an er a, an dah liau luau mai a ni.

Thangnang lo kai chhan pawh hi ngaihtuah tham a tling ve a, a rim leh zun avangin a awmna hmun a tichhe lo va, rannung dang ei tur a pûrin a tihtlem phah lo va, tumah a sehin a zun khum ve lo va; thlangdar dang hi chuan an zun hi mi mit tihdel tum ang fahranin zun khum an ching a, thangnang hi thlangdar lam chi tho ni mahsela, sualna a nei lo, kan Lalpa lei mihringte tan a rawn inpe tawp ang khan thangnang pawh hi Zoram mipui ṭam tur ṭanpui nan an taksa leh an nunna an rawn inpe ve tawp mai a ni. Pathianin chuti ang ti thei turin, chhunah sava leh hmelma dang lo tibuaitu turte zawng zawng pumpelh turin, Radar ṭha bik, Night Finder & Navigation changkang lutuk anmahnia pathianin a dah hi eng anga ril, ṭha leh thuk nge tih hi scientist changkanghote tan pawh Research beihna tham a tling a ni. Kan thlaler manna, kan vahmim, kan tan liau liauva Pathian rawn tirh a ni ang. India ram hmun hrang hranga kan mi thiam awm darhte pawhin, an awmna ram ṭheuhvah he thangnang ang hi a awm ve em? Chuta mite chuan eng tin nge an tih ve, tih te pawh hi rawn hriat tum teh se.

Sazu puan vak chhan:

Mautam laia sazu puan chhan ber chu mau rah an ei vang a ni kan ti tawh a; Mizoram-ah hian sazu hi a tam ve hrim hrim a, a duhzawng tak an eiin, an no an ei lohvin an pung chak ta em em a ni tih pawh kan sawi tawh a; heng bakah hian pun theihna dang a la awm leh a, chu chu ram pawn aṭanga lo pem lut an tam vang a ni, tih kan sawi dawn.

Min deptu ram; Burma, Bangladesh, Tripura, Cachar leh Manipur ramte hian kan ram hrulah hian mautak hi an nei ve vek a, kan mau a tâm vel lai bawk hian an tâm ve a; mahse keini angin an ngah lo va; chuta mau rah an ei zawh hnuah Mizoramah an lo lut ṭhin a ni. May thla lamah khan, Mara Dist. Burma dep Siata leh Ainak inkarah Burma aṭangin sazu rual a lo lut huk tih hriat a ni a; June thla lamah khan Manipur lam aṭangin an lut bawk tih hriat a ni a, a hmahruai an la ni lek ang.

Sazu chet dan:

Sazu chet dan hi chi hnihin ṭhen theih a ni, pakhat chu, mahni chettlatna bik chinah (local movement), a dang chu, a huhopuia chet velna (Grouping wide movement). A tlangpuiin mahni lo velah hian eng emaw zat hi chu an che reng tho va, chu chu an lo pun tak hle phei chuan mahni chenna lo khat ei chhe tham an tling ve reng reng a, tin, mahni area an tihchhiat hnuin ṭhenawm rite lo lamah an kaiin nasa takin hna an thawk thei ṭhin a, hetiang hi chu eng kumah pawh zuva zual kum an tih ṭhin thlentu pawh hi a ni a; Mautam lai pawhin hetiang tho hi lo tam tak tihchhiat dan a ni.

Amaherawhchu Mautam lai leh Ṭhingtam laia a kawng kanna an hmuh, bawng rual kalna ang maia pe hen hun ṭhin ang chi hi chu ram pawn lam aṭanga a huhopuia lo lut leh Mizoram (local) a lo awm sa, a rualpui zawm ve ta te infin khawm, a chhiara chhiar sen loh, thlawhhma bei tura an thawm thlipui lo thawk tur ang deuh mai hi chu, awmhmun nghet nei lova vak dul dula an thlen chin chin eizo duak duak mai an ni a, an tam dan tur pawh nuai tam tak a ni ringawt mai a ni. Chuti anga mi buh seng lai ni tlak hmaa an rawn chuhpui chu, Lokicherra (Zawlnuam)ah Pu Thanghmingliana buh (ṭai) a hlawhfa mi 10 nena an buh seng lai, 25.8.1976-ah khan sazu chhiar sen lohva tamin an chuhpui ta huk mai a, anni’n dan tumin tiang nen an ṭang a, an dang zo ta lo va, khuain a thim hnan ta si a, sazu 270 an vaw hlum hmana engah mah an ngai lo, chumi zan chuan buh lak loh chu an ei fai vek tho a ni. Tripura dep a nih chu.

Kum 1959 Mautam kum pawh khan Sangau khuaa cheng K. Sangchhum, Ex-Dy. Speaker naupan laiin, a ṭhian nen an ramkal hawng, tlaiah, an thlamah an chawl a, buh lak hun ṭep tawh October thla a ni; thlipui lo thawk ri ang deuh, ri hum hum an hria a, sazu rualin an lo a rawn bei dawn a, an lo thawk ri a ni a, an lo thleng chuan buh lak mai tur chu an rawn bawh ta hum hum mai a, ruam zawla buh vui let tup mai chu a phut hian a phu dul dul mai a; ni pawh a la tla lo na a, rapthlak an ti a, an tlanchhiat san daih. A tuka a pa te an zuk kal chuan buhvui pakhat mah a awm tawh lo, A nu phei chu a ṭap ringawt. Hei pawh hi *Burma* ramri hnaih a ni.

Ngaihtuah chiang teh u, Ṭhingtam leh Mautam laia Mizoramin sazu a ngah turzia hi in chhut ṭhin em ?

1911	Mautam, sazutûr hman tur pawh a la awm hma khan sazu mei, sawrkarin a leisak chu - 179015 a ni, sazuin an hek tih an inhre lo.
1929	Ṭhingtam khan, sawrkarin sazu mei 1,500,000 a lei.
1959	Mautam khan, sawrkarin sazu mei 2,100,000 a lei.
1977	Ṭhingtam khan, sawrkarin sazu mei 2,600,000 a lei.

Heng figure tamzia en hi chuan sazu chuti zozai a awm thei dawn em ni? tih mai tur a ni a, mahse hetih laia Mizoram sazu 1000-a 1 an thatin sawrkarin a lo lei chauh a ni tih hre teh. Heng hun laia sazu tam turzia hi lo suangtuah teh u; hmun khata che vek lo pawh ni se, a hlawm lian tam turzia hi kan rin phak bak daih a ni.

Thawhhona (Co-operation):

Ṭampui takmeuh lo thleng turah hi chuan a tuar tur, a bikin loneimite'n sawrkar chakna leh thuneihna hmanga an nunna hnar ber an buh leh bal an humhim theihna tura thawhhona ṭha an neih theih chuan chu tluka ṭha beisei tur dang a awm lo.

Ṭampui a thlen tak tak hma daih aṭang hian, loneimite chuan sazu kut an tuar mawlh mawlh tawh a, a rampum a huap lo tih chauh a ni a. Hengte hi sawrkarin chhawmdawlna pe thei lo mahsela, beisei pawh an beisei nahek lo; amaherawhchu sawkarin an tuarnate a hriatpui a ni tih leh, an thlawhhma himna a duhsak a ni tih hriat nan hetiang Ṭampui, sazu vanga thleng tur a nih hriat na na na hi chuan, ṭâm thlentu tur sazu thah manah a mei man (bounty) hi chu, tun hma zawng zawng ang bawkin siam awm tak chu a ni a; tum ṭum Mautam turah erawh hi chuan helam kawnga loneimite nena thawhhona hi chu a awm ta lo zawng a nih hi. Mizoram Ṭhingtam leh Mautam chanchin ziaknaa sawrkarin loneimite chhan nan sazu chuti zat, sum chuti lai sengin hna an thawk tih tur a awm dawn ta lo a ni

Inṭanpui tawnna:

Hei hi Mizo zinga kan mawina ber pakhat a ni ṭhin a; tlawmngaihna laimu a ni. Tlawmngaihna tih thu han lam ngawt pawh hian mizo tak tak rilruah chuan a lut thuk hle a; hnamdang hian 'Tlawmngaihna' tih thu tak hi chu an nei ve lo an ti hial ṭhin a; mi tlawmgngaite tih ang hi chu Mizo ai hlei hlei pawhin thil ṭha an ti thei ang a, an ti bawk a; mahse thu pakhat (word)a nei an awm lo em ni ang aw; hrilhfiah vak a ngai ṭhin.

Mizoramin Ṭampui Mitthi an lo tawn tawha thu mawi ber chu, "Sem Sem Dam Dam" tih hi a ni. Sazu ral lianin khaw khat lo a han seh duak duak mai a; mi tam zawk takin seng tur an neih hauh loh lai khan lo ṭhenkhat chu a lo him hlauh mai a; chung mite chuan, "Kan khawtlang chhan nan Pathianin min humsak a nih hi," tiin an buh thar chanve lai te a thlawn ngatin kum thar thlawhhma lak leh nan an han sem ral vek mai a, chutianga a chi an lo neih theih avang chuan khaw khat an lo intungnung ṭhin a ni; hei hi a mawi em em a ni; tunlai hunah pawh mi tam takin hetiang rilru hi an lo pu fo tawh tih hriat te hi a nuam hle a ni. Tui lian avang emaw, harsatna dang vang emawa khawpui pawhin ei leh bara harsatna a tawh chang pawha mahni neih sa thukru mai lo va, vantlang tana an han phawrh ngat mai zawk te hi, Tlawmngaihna dik, Mizo ze dik tak kha a ni.

Hei Ṭampui mitthi kan lo hmachhawn leh ta mai a, hemi hun khirh tak lo thleng turah pawh hian Mizo ze dik tak, hnam dang rilru pawlh dal loh kha chhuah turin i inpeih ang u.

MAUTAM - PRESENT SCENARIO vis-a-vis GOVERNMENT PERSPECTIVE

James Lalsiamliana
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Department of Agriculture
Government of Mizoram

A. PRESENT SCENARIO

1. SPORADIC BAMBOO FLOWERING:

Survey of bamboo flowering areas was started from the month of March, 2002 to till date. Observations obtained during the survey were as follows

Species of flowering bamboo	**Flowering intensity**	**Month(s) of occurrence**
Melocanna baccifera (Mautak)	Sporadic	a) July 2001 b) February - July, 2002 c) March - July, 2003 d) March - July, 2004 e) Feb - July, 2005
Dendrocalamus hamiltonii (Phulrua)	Sporadic	a) Oct - Dec 2001 b) June, 2002. c) March, 2003 d) March, 2004 e) Feb - April, 2005

A sporadic flowering of *Melocanna baccfera* was observed from the month of February and last till July, with a peak of flowering and fruiting during the months of June and July.

2. YEAR-WISE OBSERVATION OF SPORADIC FLOWERING OF *Melocanna baccifera:*

a) 2001 - 3 locations
b) 2002 - 33 locations
c) 2003 - 25 locations
d) 2004 - in almost all the bamboo growing areas
e) 2005 - in all the bamboo growing areas

3. GREGARIOUS FLOWERING OF *Melocanna baccifera*

During the month of January to July 2005, a gregarious flowering of *Melocanna baccifera* was observed at Suangkuang-zau at Mamit District in the western part of Mizoram, covering an estimated area of 500 hectares.

During the month of October, 2005, an initial gregarious flowering of *Melocanna* *baccifera* was observed in the Chawngtlai bamboo area, near Khawzawl, under Champhai District, covering an estimated area of 10 hectares. By the month of February and March, 2006, a gregarious flowering is observed in the following places -

Khawhai to Saitual	Champhai District
Baktawng to Chhingchhip	Serchhip District
Bilkhawthlir	Kolasib District
Paikhai	Aizawl District
Eastern parts of Kolasib	Kolasib District
Dawn to Haulawng	Lunglei District
Serkhan to Bukpui	Kolasib District

It is estimated that 1/4th of the total bamboo growing areas in Mizoram is under gregarious flowering during the year 2006.

4. THANGNANG (A hemipteran bug) - an indicator of Bamboo flowering

Our forefathers used to predict arrival of swarms of a Hemipteran bugs, locally called Thangnang, as an indicator of imminent gregarious flowering of *Melocanna* and famine. This bug belongs to the pentatomidae and they are not known to attack crops. A specimen were sent to the Forest Research Institute, Debra Dun on 16 May, 2006 and, Dr. S. Singh of the National Forest Insect Collection, Forest Research Institute, Debra Dun identified the bug as *Ochrophara montana* Distant.

Swarms of these bugs were first observed to herald Mautam 2007, during the first week of May 2005 at N. Sabual Village, near Mamit Town, under Mamit District. During the year 2006, swarms again appears in from the following places -

N.Sabual (near Mamit Town)	Mamit District
Kawrte	Mamit District
Sakawrdai	Aizawl District
Tlungvel	Aizawl District
Sakawrhmuituai	Aizawl District
Zotui-tlang	Lunglei District
Palsang	Aizawl District
Lungsum	Aizawl District
Saichal	Champhai District
Dampui	Mamit District
Hualtu	Serchhip District
Zawngin	Aizawl District

5. SURVEY OF RODENT INCIDENCE AND THEIR POPULATION:

During the year 2002-2003

Rodent incidence was observed in 34 villages.
Severe incidence was observed on 3 villages- Tlangpui, Tlangpuite and Parva.
Moderate incidence on 18 villages and
Low incidence was on 13 villages.

These rodents were found attacking standing paddy crop.

During the year 2003-2004

Rodent incidence was observed in 16 villages.
Moderate incidence was observed on 5 villages and
Low incidence was on 11 villages.

During the year 2004-2005

Low incidence of rodent was observed on 50 villages.

During the year 2005-06

Quarterly rodent survey on Jhum and WRC areas by quadrate and diagonal method, respectively, as per suggested by the Central Rodent Management Team, headed by Dr. AMK Mohan Rao, during their November 2004 visit, is done in all the 53 Agricultural Circles by the Agriculture Officer in charges.

Out of 53 agricultural circles in the state, two villages each from each circle (total 106 villages) were randomly or based on frequent rodent damage reports identified through-out the state. The field extension staff at Circle level took monthly observations in each village. The details of the observations were submitted regularly to the Director of Agriculture for formulating further plan of actions. A proforma for submission of the report was issued from the Directorate of Agriculture, Aizawl, Mizoram.

Damage Assessment Under Jhum And WRC

a. During 2005-06:

The villages where more than 10% of damages were observed were as follows -

Sl No	Name of Village	Agril District	Damage percentage	
			Jhum	WRC
1.	Khawhai	Champhai	12.5	14.2
2.	Bualpui 'N'	Saiha	12.4	13.3
3.	Maubawk 'L'	Saiha	12.1	12.4
4.	Vahai	Saiha	12.1	4.7
5.	Phura	Saiha	12.0	11.3
6.	Chalrang	Champhai	11.7	12.7
7.	S.Vanlaiphai	Lunglei	11.3	-
8.	Kawlkulh	Champhai	11.3	-
9	Ngopa	Champhai	10.3	13.4
10.	Bunghmun	Lunglei	10.3	-
11.	Sangau	Saiha	10.3	6.0
12.	Dampui	Mamit	10.3	-
13.	Leithum	Champhai	2.3	12.3
14.	Phaisen	Kolasib	1.2	11.7

b. During the year 2006-07

Rodent incidences on vegetables and cereal crops were observed in the fields since the month of March-April, 2006. Rodents were found to attack Maize and Cucurbits and cutting the growing paddy stems occasionally. The incidences were however found to be low to moderate during the early growing periods.

During the last week of August and 1st week of September 2006, the incidence of Rodents on an early maturing stick paddy was found to be serious in the following jhum lands- viz. Hualtu and Phulmawi villages under Serchhip District, Khawpuar village under Aizawl District, Dulte, Puilo and Chhawrtui villages under Champhai District. All these villages fall under the gregarious flowering areas of *Melocanna* during the current year

Surveillance of rodent incidences in various crops within the state of Mizoram is essential, such that, rodent control measures maybe undertaken effectively. In order to carry out a detail rodent surveillance, a Core Members for Rodent Surveillance in every Agricultural Districts and Horticultural Divisions was established; comprising a 17 field extension staffs members, to assist Asst. Plant Protection Officer.

The Core members submitted their survey report directly to the Director of Agriculture & M.I. with a copy to their controlling District/Divisional Officers. Furthermore, Core members from Horticulture Department also submitted their copy to the Director of Horticulture, Mizoram.

Some of the villages where moderate rodent incidences were observed were as follows:

Sl.No	Village	Date of report / verify	Remarks
1	Darlawn	12.04	Seeds of paddy and vegetables were damaged by rats
2	Hmunpui (near Lengpui)	17.05	-do-
3	Phunchawng-zawl (Khawzawl)	04.05	-do-
4	Sakawrdai	03.05	-do-
5	Saiha	05.05	-do-
6	Saihapui & Bawngva	07.05	-do-
7	Kawrte(thawveng)	09.05	-do-
8	Dialdawk	15.05	-do-
9	Mualpui (Chhingchhip)	24.05	-do-
10	Lawngtlai	31.05	-do-
11	Reiek	01.06	-do-
12	Sihhmui	03.06	Maize cobs and vegetable fruits were damage by rats

13	Palsang (near Ratu)	05.06	-do-
14	Dialdawk/Hmunpui	17.06	-do-
15	Chhawrtui	19.06	-do-
16	Rasdali (Kolasib)	24.06	-do-
17	Tlungvel	22.06	-do-
18	Mimbung, Tinghmun, Teikhang, Kawlbem	23.06	-do-
19	W.Serzawl	04.07	-do-
20	Ngopa, Mimbung	06.07	-do-
21	NE Khawdungsei	12.07	-do-
22	Dungtlang, Leithum	13.07	-do-
23	Keifang	17.07	-do-
24	N .Hlimen	18.07	-do-
25	Changzawl (near Hliappui)	19.07	-do-
26	Kawlkulh, N.Vanlaiphai, Riangtlei, Sialhawk, Vangchhia	20.07	-do-
27	Tualte, Khawzawl	21.07	-do-
28	Bunghmun West	23.07	-do-
29	Khawzawl, Dulte,Saichal	26.07	-do-
30	Zawlsei, Khuangthing, Khawbung	29.07	-do-
31	N. Chaltlang	01.08	-do-
32	Farkawn, Thekte, Thekpui	03.08	-do-
33	Kanghmun, Bungthuam	05.08	-do-
34	Saisih	12.08	-do-
35	Luangpawn	24.08	-do-
36	Tualbung	30.08	Early maturing sticky rice grains were attacked by rats
37	Vaitin	01.09	-do-
38	S.Sabual	06.09	-do-
39	Phura	07.09	-do-
40	W.Phaileng	08.09	-do-
41	Sangau	08.09	-do-
42	Cheural	08.09	-do-

6. RODENT SPECIES AND THEIR HABIT AT ANALYSIS

Out of 14 different rodent species collected till 2005-06, the most likely out breaking rodent species during the coming gregarious flowering of *Melocanna baccifera,* as per their frequencies in the paddy fields, were - *Mus* spp. (Field Mice), *Niviventer* sp., *Rattus rattus* and *Berylmys* sp.

Sl. No.	Scientific name	Common name	Habitat
1	*Rattus rattus*	BlackJRoof/House rat	rice fields, godown, house
2	*Rattus nitidus*	Himalayan rat	house
3	*Bandicota bengalensis*	lesser bandicoot rat	godown
4	*Mus museulus*	House mouse	houses
5	*Mus* sp.	Mouse	rice fields
6	*Niviventer* sp.	Spiny Forest rat	forest, rice fields
7	*Bery/mys mackenziei*	Mackenzie's rat	forest, rice fields
8	*Leopo/damys edwardsae*	Rattan rat	forest, rice fields
9	*Cannomys badius*	lesser bamboo rat	forest, plantation areas
10	*Chiropodomys gliroides*	Bamboo mouse	bamboo forest
11	*Rattus norvegicus*	Laboratory/Norway rat	as a house pet
12	*Rattus exulans*	Pacific rat	rice fields
13	*Mus nagarum*	Nagarum mouse	rice fields
14	*Mus bodooga*	Pygmy mice	rice fields

7. PUBLICITY, AWARENESS CAMPAIGN AND TRAINING

Training of farmers is being conducted in the villages and fields. Farmers were trained in the biology of rodents and use of rodenticides and, practical works were done in the fields. The training programme is still going on to cover as much villages and towns as possible.

Leaflets, notes and booklets on rodents and their control were distributed to the farmers free of cost

A documentary films on rodent control are being utilized in the training programmes and, also the Departmental activities on Rodent control, viz. rodent and bamboo flowering surveys and, interviews of farmers on bamboo flowering and their past experiences were broadcasted frequently through audio-visual medias, such as Aizawl Doordharsan and local Cable TV networks.

Training of Trainers was organized in collaboration with the Central Young Mizo

Association (CYMA) the largest NGO's in Mizoram and, All Mizoram Farmers Union (AMFU) throughout Mizoram within the month of September, 2006. The training programme covers all the branches of YMA and AMFU.

8. USE OF LOCAL RAT TRAPS

Farmers were encouraged to use Rattraps, such as Single-capture kill-traps or snares (e.g. Vaithang, Thangchep, Hawlh-tawt, Mangkhawng,) and Live-traps (e.g. Cage traps).

The Department also tested the efficacies of Linear trap barrier system by using multiple capture Cage Traps in some of the selected jhum and forest areas.

9. USE OF RODENTICIDES

Rodenticides were procured and distributed to the farmers, through the concern District Agricultural Offices, as per the intensity of rodents' incidence.

Sl. No	Year	Rodenticides	Quantities (in Ks)
1.	2002-03	ZincPhosphide	250
		Bromodiolone (Cake)	600
		Bromodiolone (Conc.)	100
2.	2003-04	Zinc Phosphide	100
		Bromodiolone (Cake)	3,000
		Bromodiolone (Conc.)	500
3.	2004-05	Bromodiolone (Cake)	3,500
		Bromodiolone (Conc.)	550
4.	2005-06	Bromodiolone (Cake)	11,050
		Bromodiolone (Conc.)	800
		Zinc Phosphide	500
		Aluminium Phosphide	200

10. INTERNATIONAL PARTICIPATIONS

The unique phenomena of a periodical gregarious flowering of bamboo, which leads to famine in Mizoram in the past years, attract from far and near. Various participants from abroad were as follows

1. Dr. Valerie C. Grossman BEd, Dip. H.R.A., M.A.(A.B.S), M.A.(H.D.), Ph.D, from Calgary, Canada came to Mizoram during the year 2001 in connection to Educational System in Mizoram. When she learned about the phenomena of bamboo flowering in Mizoram, she voluntarily returned with Mr. John Brian Bourne, Rodent Pest Specialist, Department of Agriculture, Alberta, Canada in November 2002. After meeting and interviews, they work out a **'Narrative Based Strategic Action Plan for Mautam 2007, Mizoram India.'**

The prepared Action Plan was based on the information collected from various individuals and the strategies includes

a) Integrated rodent management plan without bounty system
b) Mobilization of human resources from farmers and NGOs
c) Identify the cause of outbreak
d) Emergency use of specific different rodenticides like, Difethialone, Difenacoum, Brodifacoum etc.
e) Diversified jhum and not paddy based
f) Awareness for the people
g) Improved infrastructure, like roads and border trade
h) Flexible government policies on provision of funds and aids

2. Dr. Ken Aplin, Wildlife Biologist from CSIRO, Australia was introduced to the Minister of Agriculture, Government of Mizoram, by Dr Valerie Grossman. Through the invitation of the Minister, Dr. Ken Aplin visited Mizoram during the month of March, 2004. During his one week stay, he visited some of the jhum land and forests. Dr. Ken Aplin's recommendations for the coming Mautam were as follows

- Further rodent survey work should be carried out, especially in the eastern mountainous area and on the plains, to continue the process of documenting the current status of the rodent fauna of Mizoram prior to the 2004-2006 Mautam events.
- In view of the uncertainty over the likely effectiveness of each of the suggested chemical and non-chemical methods of rodent control, consideration should be given to conducting experimental trials of proposed methods in areas that experience early flowering of *Melocanna baccifera.* Any such trials would need to be carried out under a rigorous experimental design and would need to be ready to commence in late 2004 or early 2005, when the next cohort of *Melocanna* is expected to commence flowering. Rodent population monitoring would represent an integral part of any such design.
- Ahead of the trials suggested in Recommendation 2, work would need to commence on the design and testing of multiple capture traps suitable for stand-alone use and as components of LTBS (linear trap-barrier systems). Work on the design of LTBS fencing should also proceed at the same time.
- Consideration should be given to ways in which *Melocanna* seed might be harvested and processed as a means of income generation during Mautam.
- In view of both the seriousness of the impending Mautam crisis and the international relevance of Mizoram's efforts to combat the crisis, consideration should be given to seeking international financial assistance to carry out the studies and trials recommended under Recommendations 1-4. Possible funding sources could include FAO's Technical Cooperation Programme and the Rockefeller Foundation.
- As a separate issue, consideration should perhaps be given to restricting the domestic keeping of *Rattus norvegicus.* This species poses a considerable threat if becomes established as a feral animal in Mizoram.

keeping of *Rattus norvegicus*. This species poses a considerable threat if becomes established as a feral animal in Mizoram.

3. An 8 member team of Japanese bamboo scientists, headed by Dr. Shozo Shibata, Associate Professor, Kyoto University, Tokyo, Japan, after obtaining funds from their own Government, came to Mizoram during the month of November, 2005. They plan to conduct research on Gregarious flowering of *Melocanna*, a species, which was not available in their country. The Japanese Government sponsored their research project for 4 years.

B. GOVERNMENT PERSPECTIVE

BAMBOO FLOWERING AND FAMINE COMBAT SCHEME (BAFFACOS)

The Government of Mizoram, as per suggested by the Chief Minister, has initiated the formulation of a comprehensive programme of assistance for the farmers to combat bamboo flowering and famine, with an aim to reduce poverty among the farmers during famine period. It is expected that gregarious bamboo flowering will take place around 2006 and 2007.

The programme, Bamboo Flowering and Famine Combat Scheme, BAFFACOS, in short, was chaired by the Chief Secretary to the Government of Mizoram and The State Planning Department as the Nodal Department. The programme is inter-linked with 13 different Departments under the Government of Mizoram, viz. Environment & Forest, Food & Civil Supplies, Agriculture, Industries, Rural Development, Health Services, Horticulture, Soil & Water Conservation, Animal Husbandry & Veterinary, Land Revenue & Settlement, Sericulture, Fisheries and Social Welfare.

The Cabinet Meeting desired that the funds for BAFFACOS be utilized in a more meaningful manner which can have direct impact on the rural poor families by creating direct employment to them. Hence, major portion of the fund which has been allocated to the BAFFACOS implementing Departments has been pulled back for the year 2006-2007 (vide. No.G.28014/55/2006-07/SPB dated the 1st Sept. 2006)

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PROGRAMME

MIZORAM SCIENCE SOCIETY (MSS)
SYMPOSIUM ON BAMBOO FLOWERING AND ITS CONSEQUENCES

Venue : Auditorium, Pachhunga University College
Date : 3rd. October 2006, 11:00 a.m.

MORNING SESSION

Chairman : Er. Dunglena, President, Mizoram Science Society

1100 - 1105 hrs : Introductory Remarks : Chairman
1105 - 1115 hrs : Reports and Announcement : Pu C. Lalduhawma, General Secretary, MSS
1115 - 1145 hrs : Presentation : Dr. F. Lalnunmawia, Lecturer, Forestry Dept., Mizoram University.

Topic : " Eco-physiology of Bamboo Flowering"

1145 - 1150 hrs : Solo : Tv. F.P. Laltlankima, II B.Sc, PUC
1150 - 1220 hrs : Presentation : Pu K. Lalchhandama, Head, Zoology Dept. Pachhunga University College.

Topic : "Population dynamics of rats in relation with bamboo flowering"

1220 - 1245 hrs : **Refreshment**

AFTERNOON SESSION

Chairman : Dr. L.N. Tluanga, Vice President, Mizoram Science Society

1245 - 1250 hrs : Remark : Chairman
1250 - 1320 hrs : Presentation : Pu C. Rokhuma, Mission Vengthlang

Topic : " Bamboo Flowering : The experiche"

1320 - 1325 hrs : Solo : Nl. Natalia Rosangzuali, II B.Sc, ZRSC
1325 - 1355 hrs : Presentation : Pu James Lalsiamliana, Asst. Plant Protection Officer Agriculture Department, Govt. of Mizoram.

Topic : "Present scenerio vis-a-vis Government perspective"

1355 - 1420 hrs : Sharing of personal experiences
1420 - 1450 hrs : DISCUSSION
1450 - 1500 hrs : Vote of Thanks : Dr. R. Kapthuama, Vice President, MSS

Hosts : Dr. Vanlalhruaii Ralte & Pu Saitluanga, Exe. Committee Members
Recorders : Pu Aldrin Malsawmtluanga & Nl. Lalramnghaki Pachuau, Exe. Com. Members
Registration i/c. : Nl. Lalzahawmi Chenkual, Treasurer & Nl. Nancy U Thapa, Exe. Com. Member